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(54) **SURGICAL ACCESS DEVICE**

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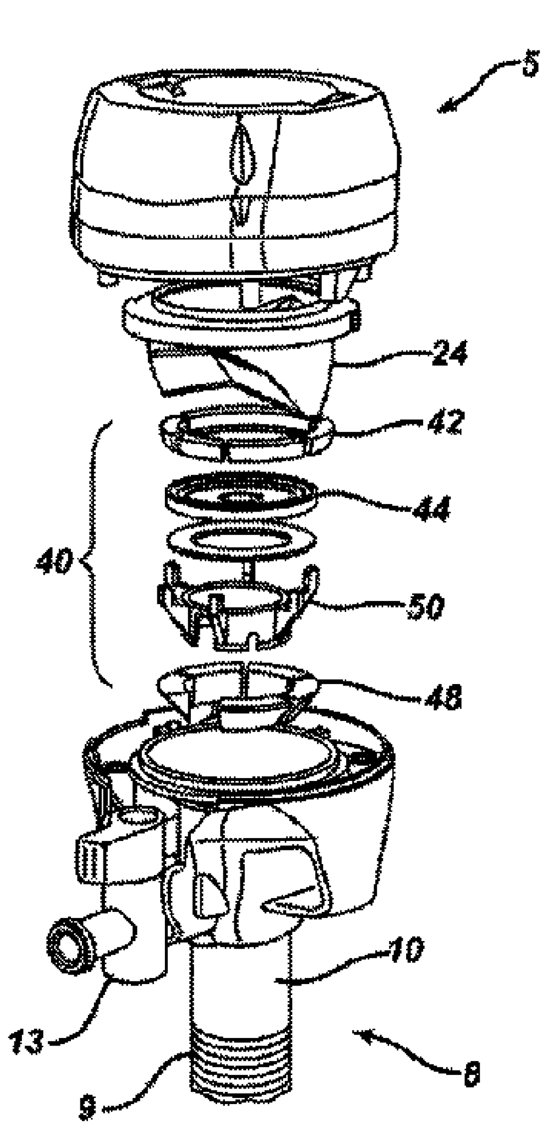
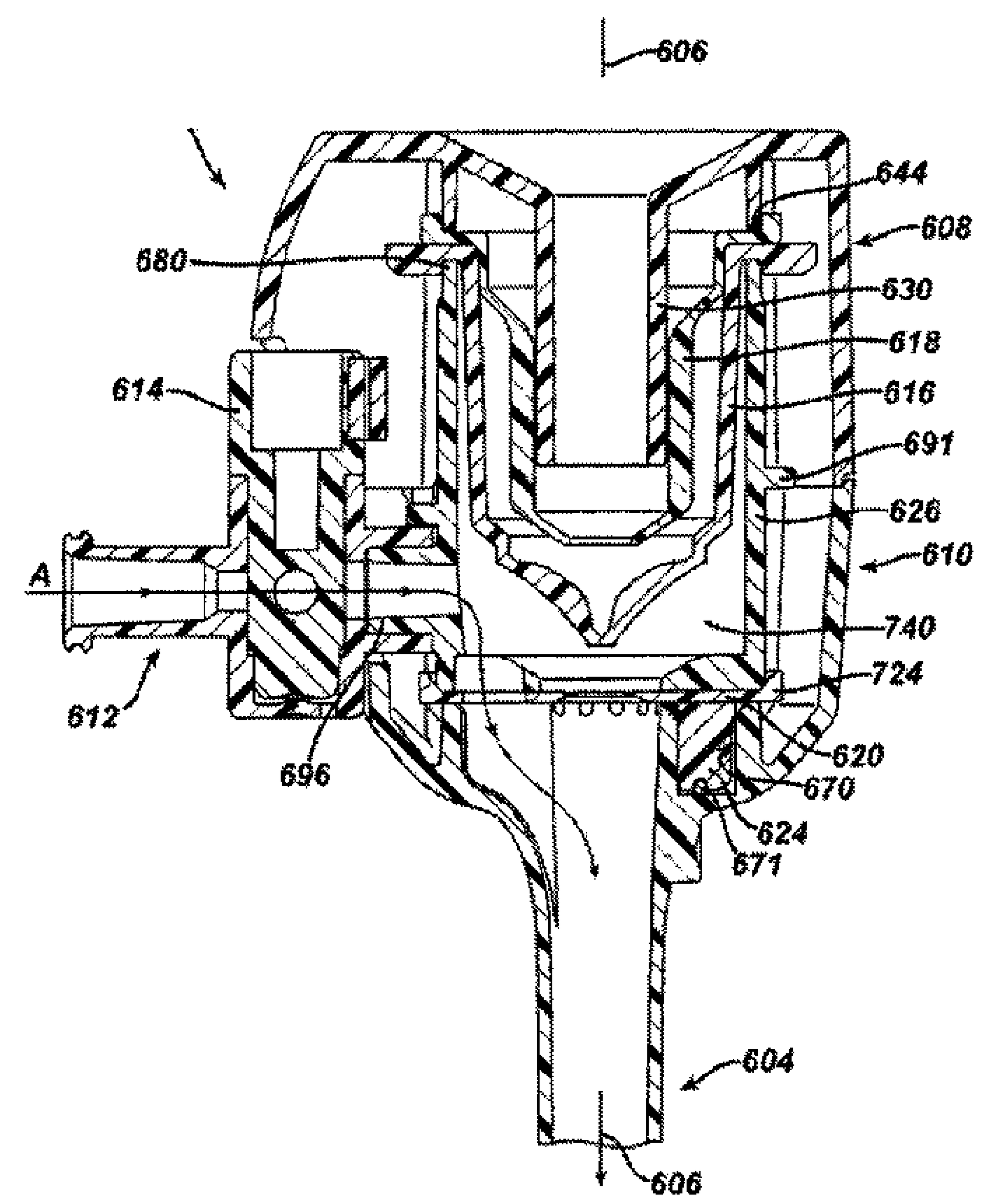
(57) **ABSTRACT**

The present invention generally provides methods and devices for removing fluid from a surgical instrument. Surgical access devices and seal systems are generally provided having one or more valves or seal assemblies to create a closed system between the outside environment and the environment in which the surgical access device is being inserted. The devices of systems can also include a fluid remover in the form of a sorbent element, a scraper element, a wicking element, or any combination thereof that is configured to remove fluid from a working channel of the device or system and/or from a surgical instrument inserted therethrough.

26 Claims, 48 Drawing Sheets





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continuation-in-part of application No. 12/533,590, filed on Jul. 31, 2009, now Pat. No. 8,568,362, which is a continuation-in-part of application No. 12/110,724, filed on Apr. 28, 2008, now Pat. No. 8,579,807, and a continuation-in-part of application No. 12/110,727, filed on Apr. 28, 2008, now Pat. No. 8,870,747, and a continuation-in-part of application No. 12/110,742, filed on Apr. 28, 2008, now Pat. No. 9,358,041, and a continuation-in-part of application No. 12/110,755, filed on Apr. 28, 2008, now Pat. No. 8,273,060.

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FIG. 1A

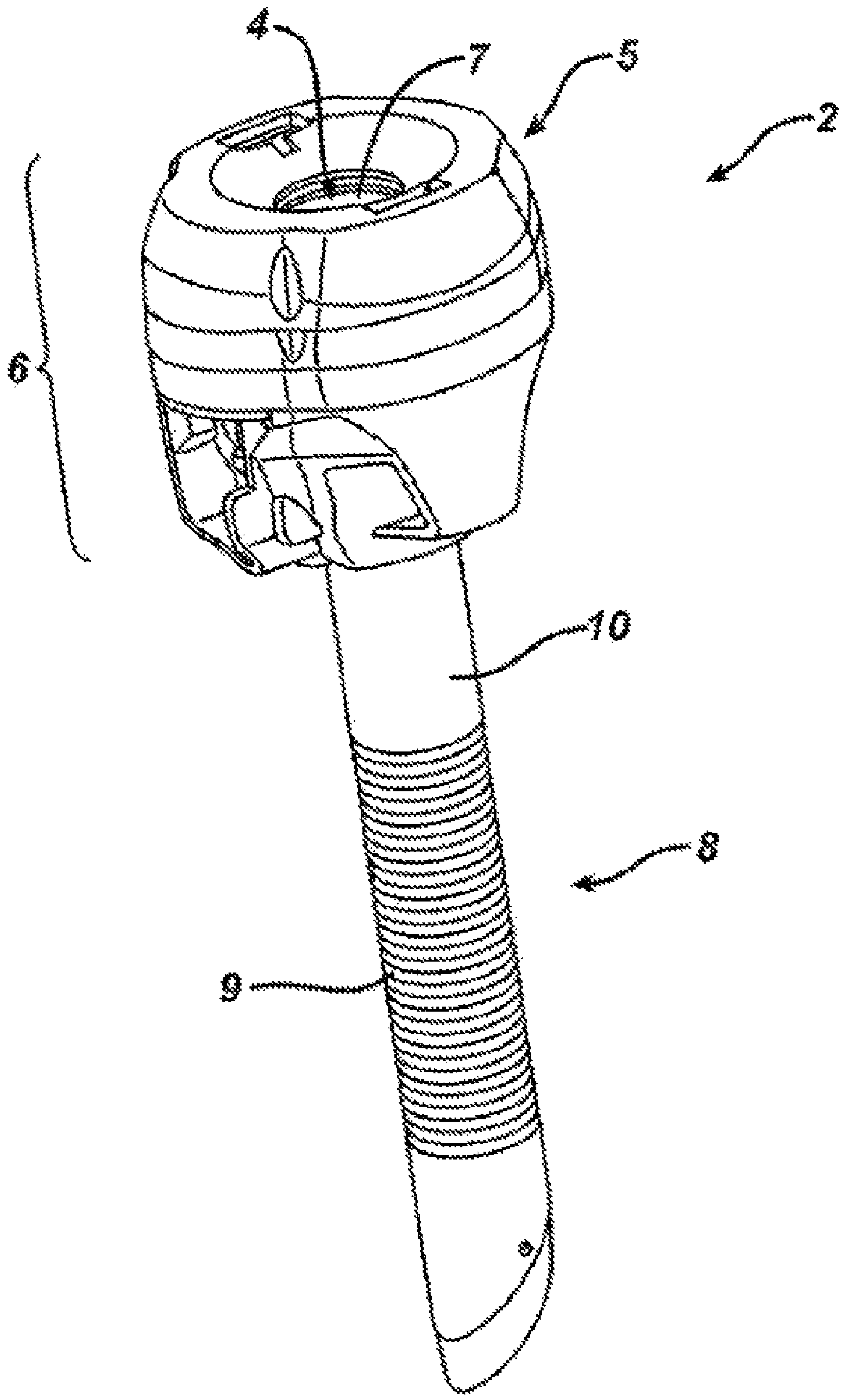


FIG. 1B

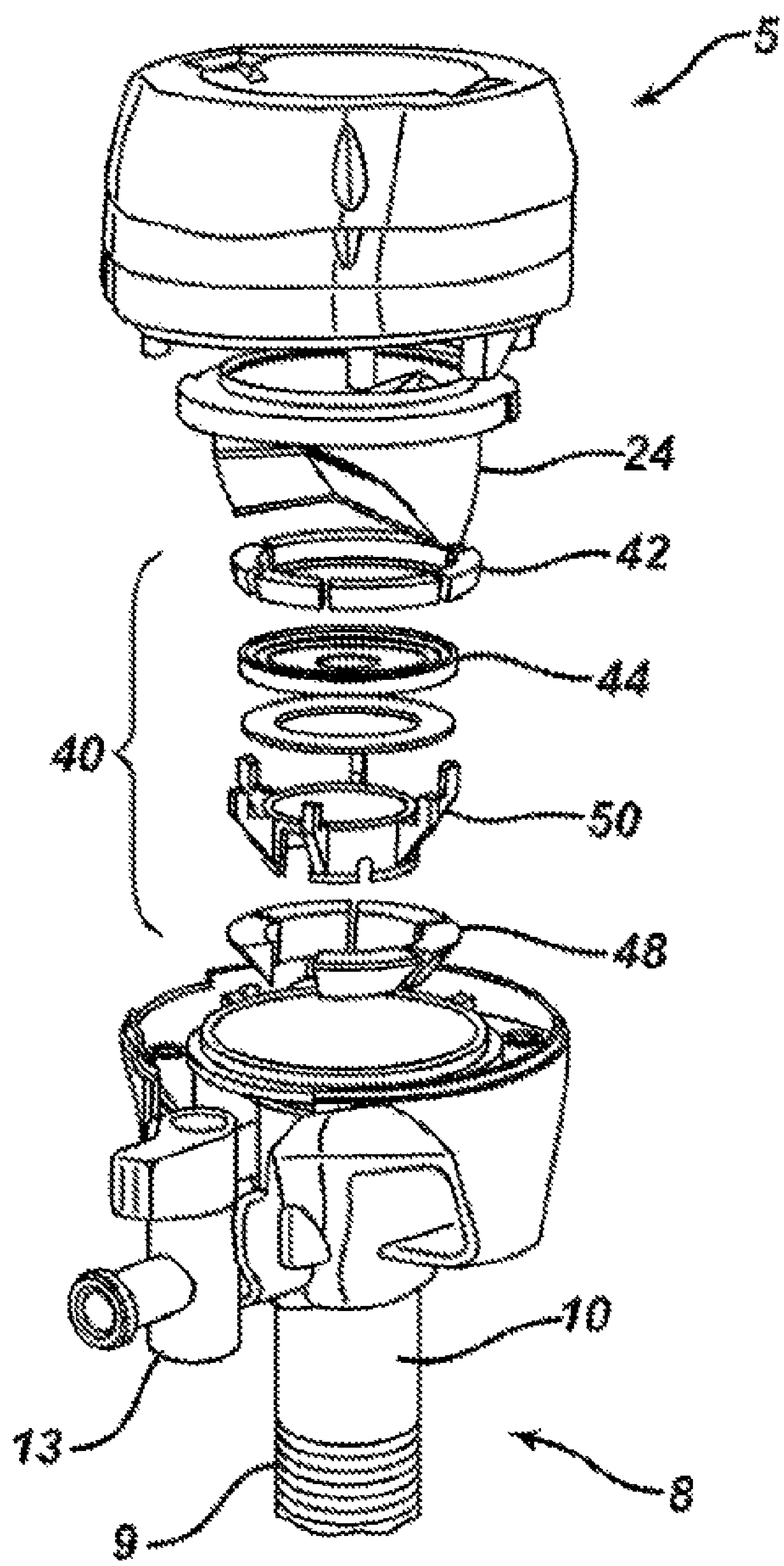


FIG. 1C

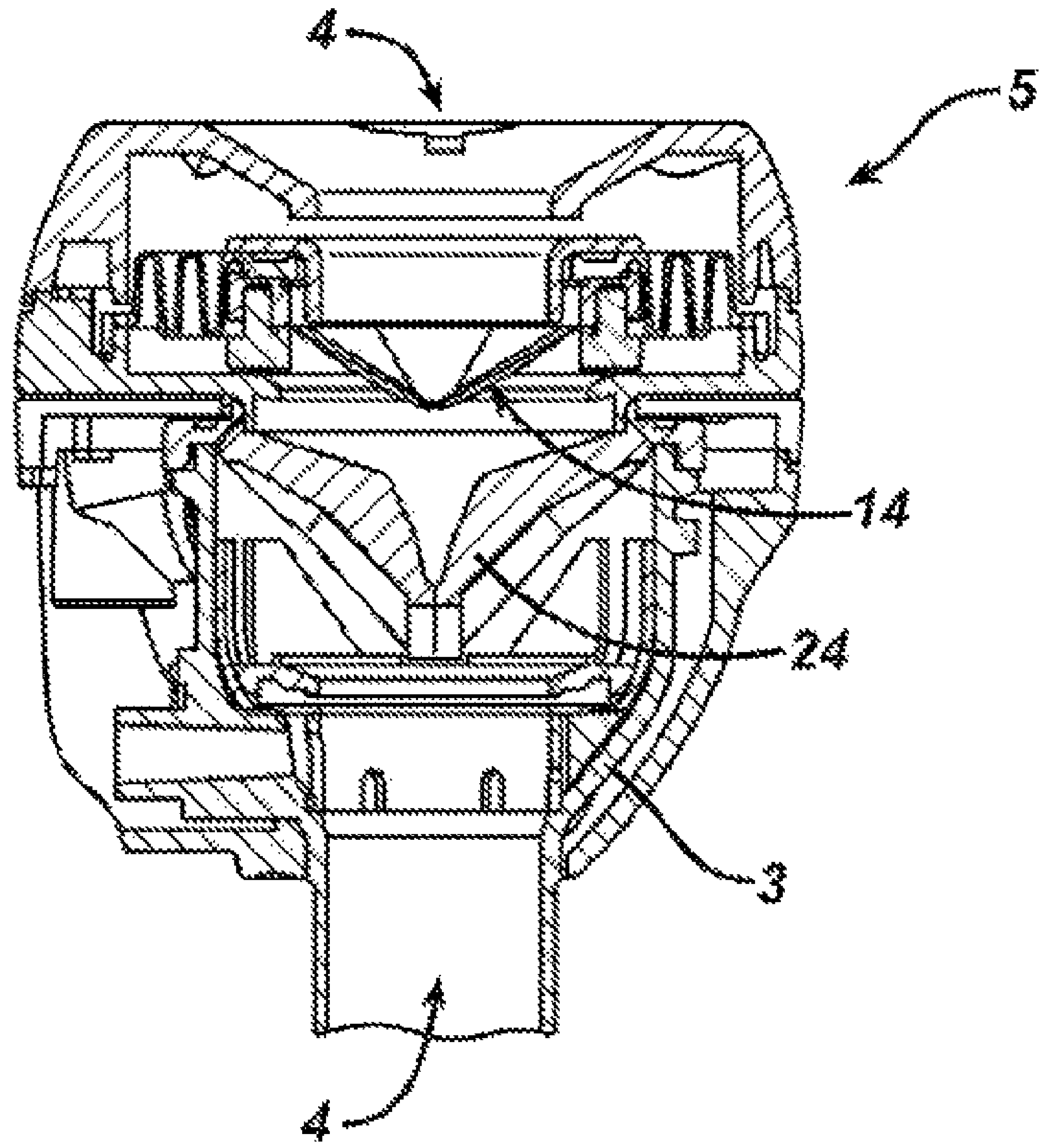
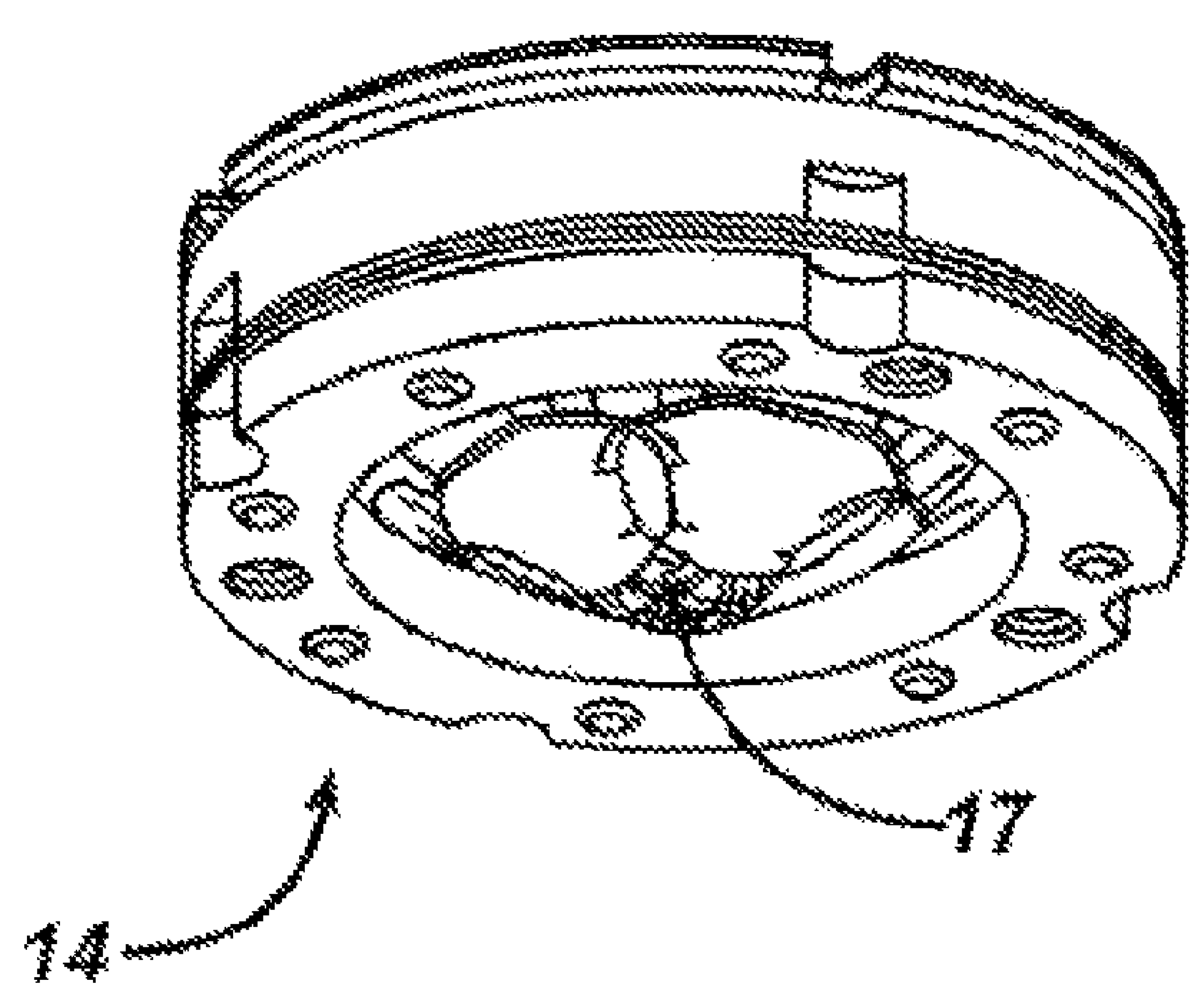


FIG. 1D



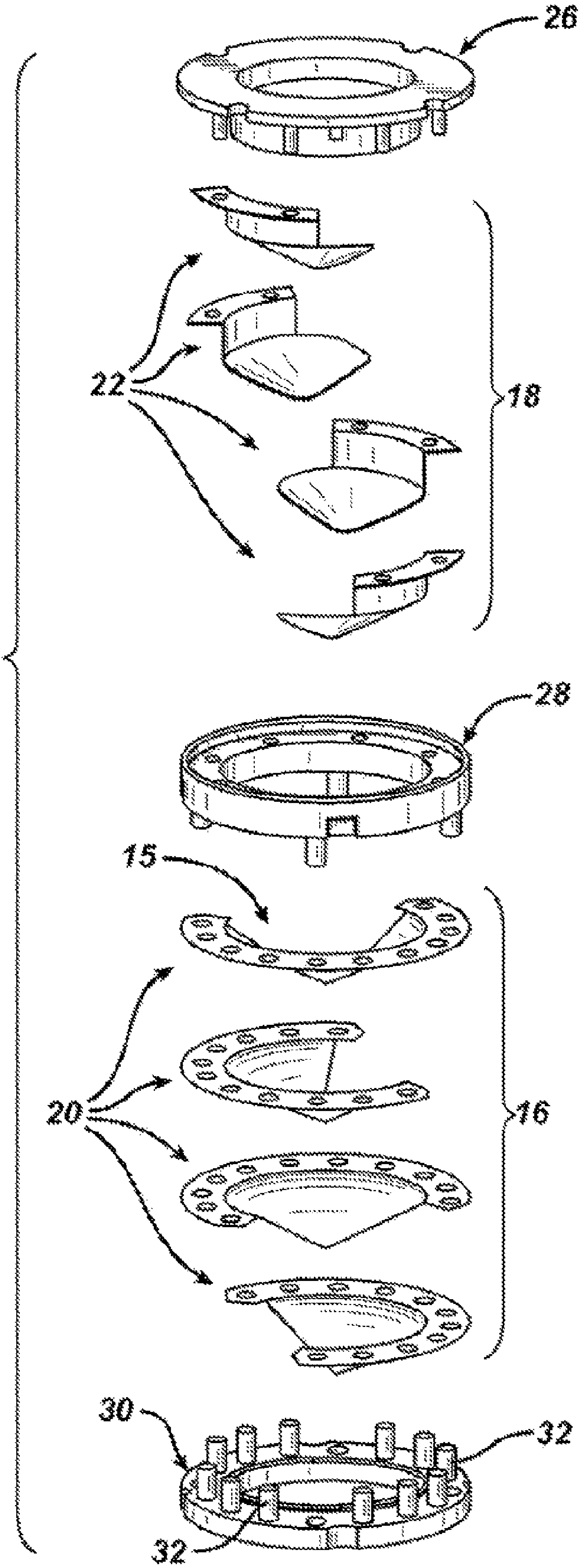


FIG. 1E

FIG. 1F

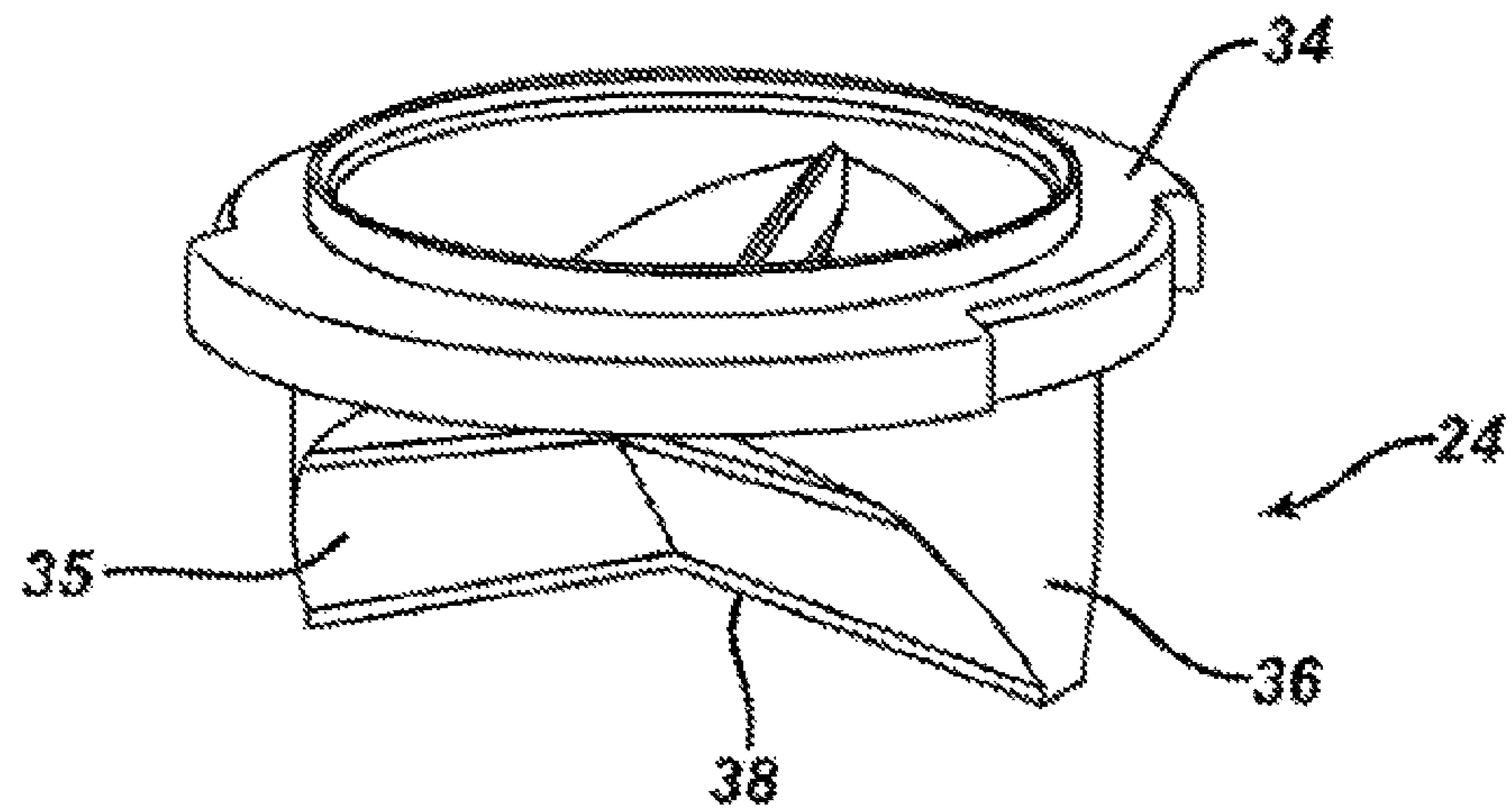


FIG. 1G

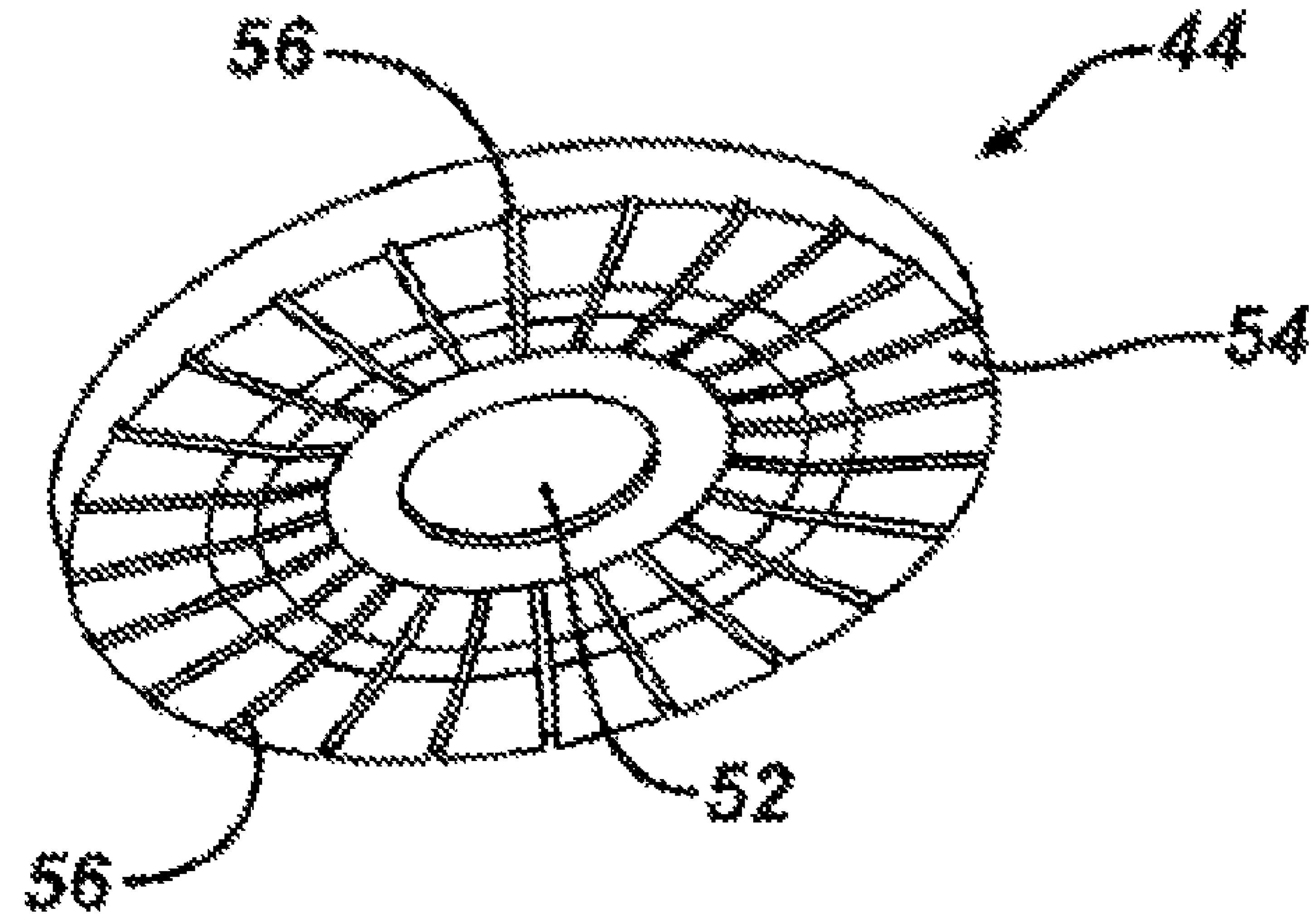


FIG. 1H

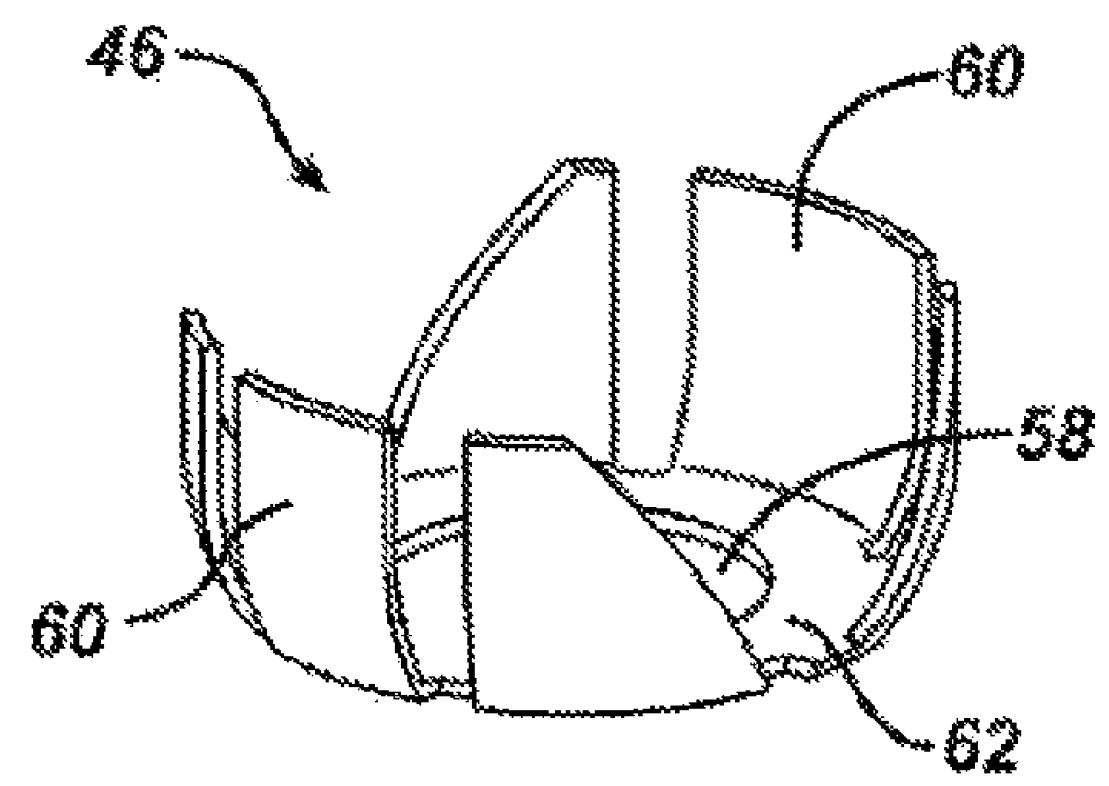


FIG. 1I

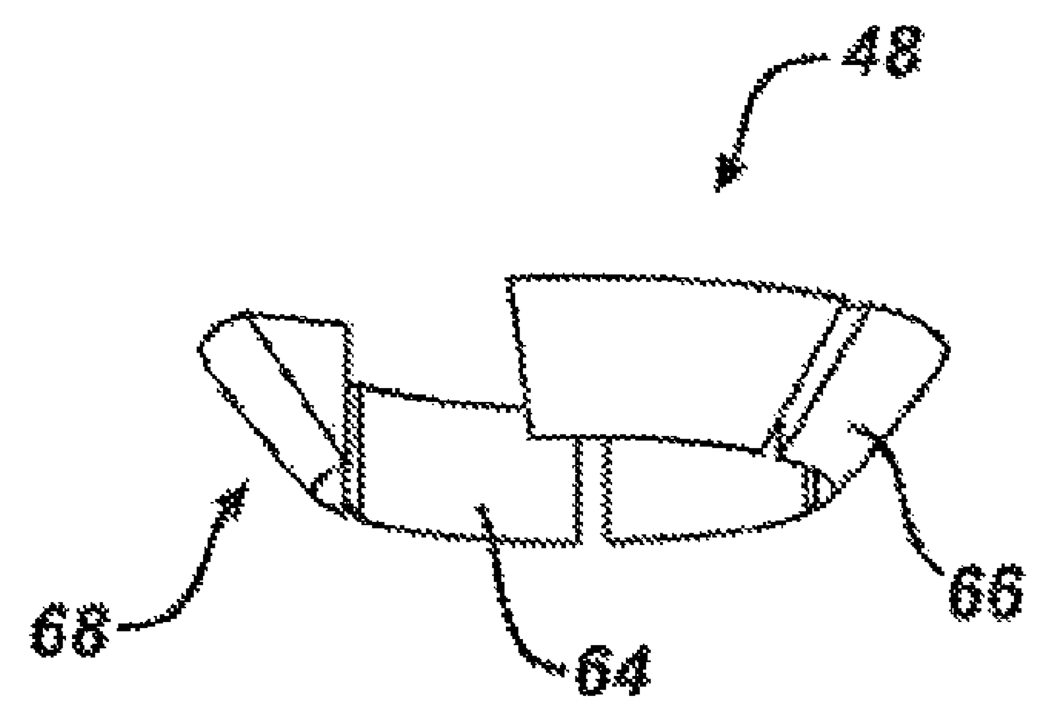


FIG. 1J

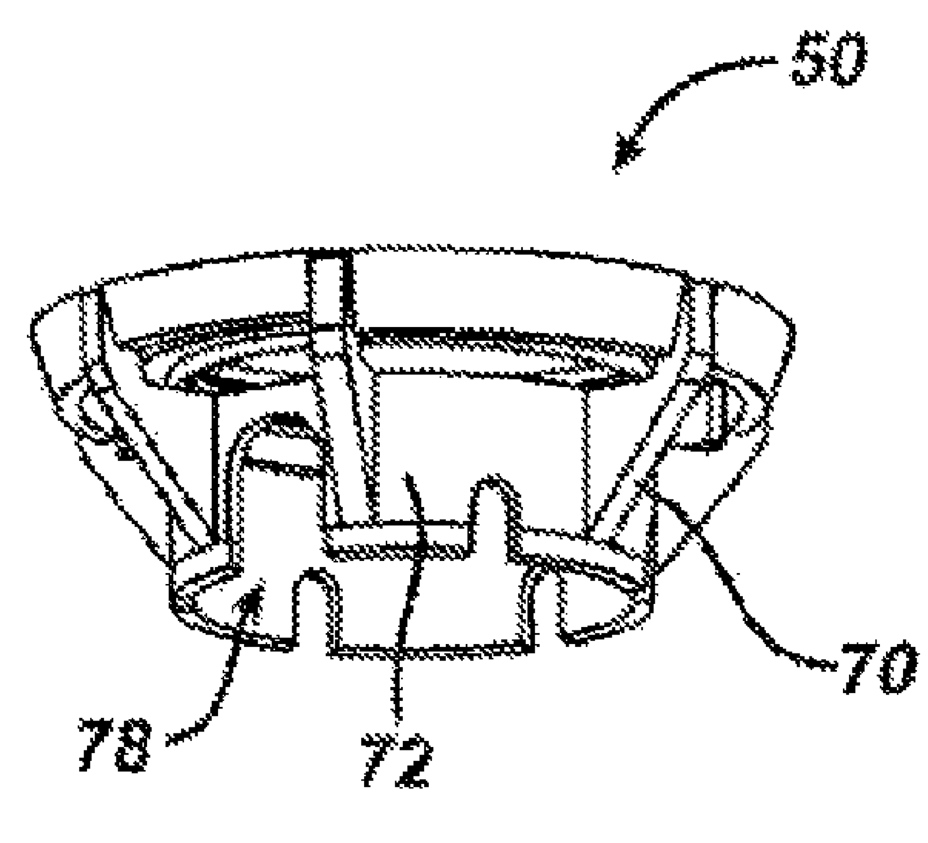


FIG. 1K

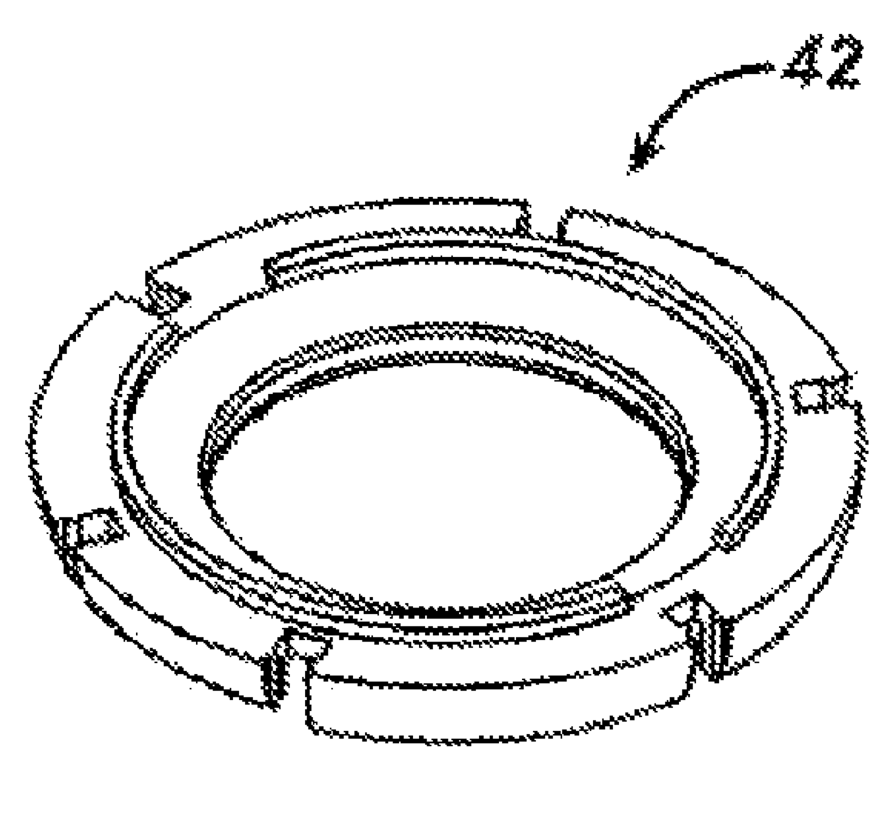


FIG. 2A

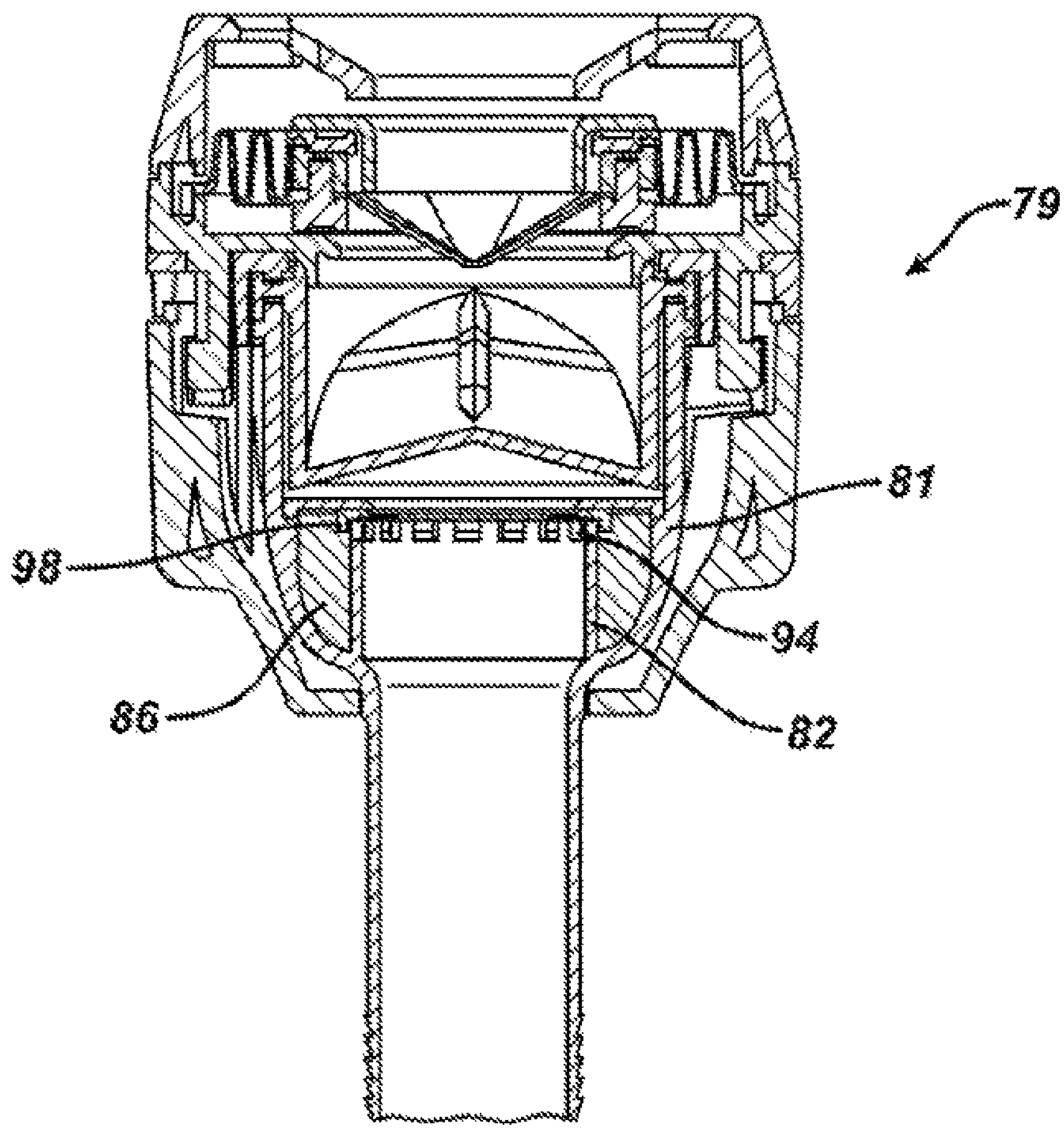


FIG. 2B

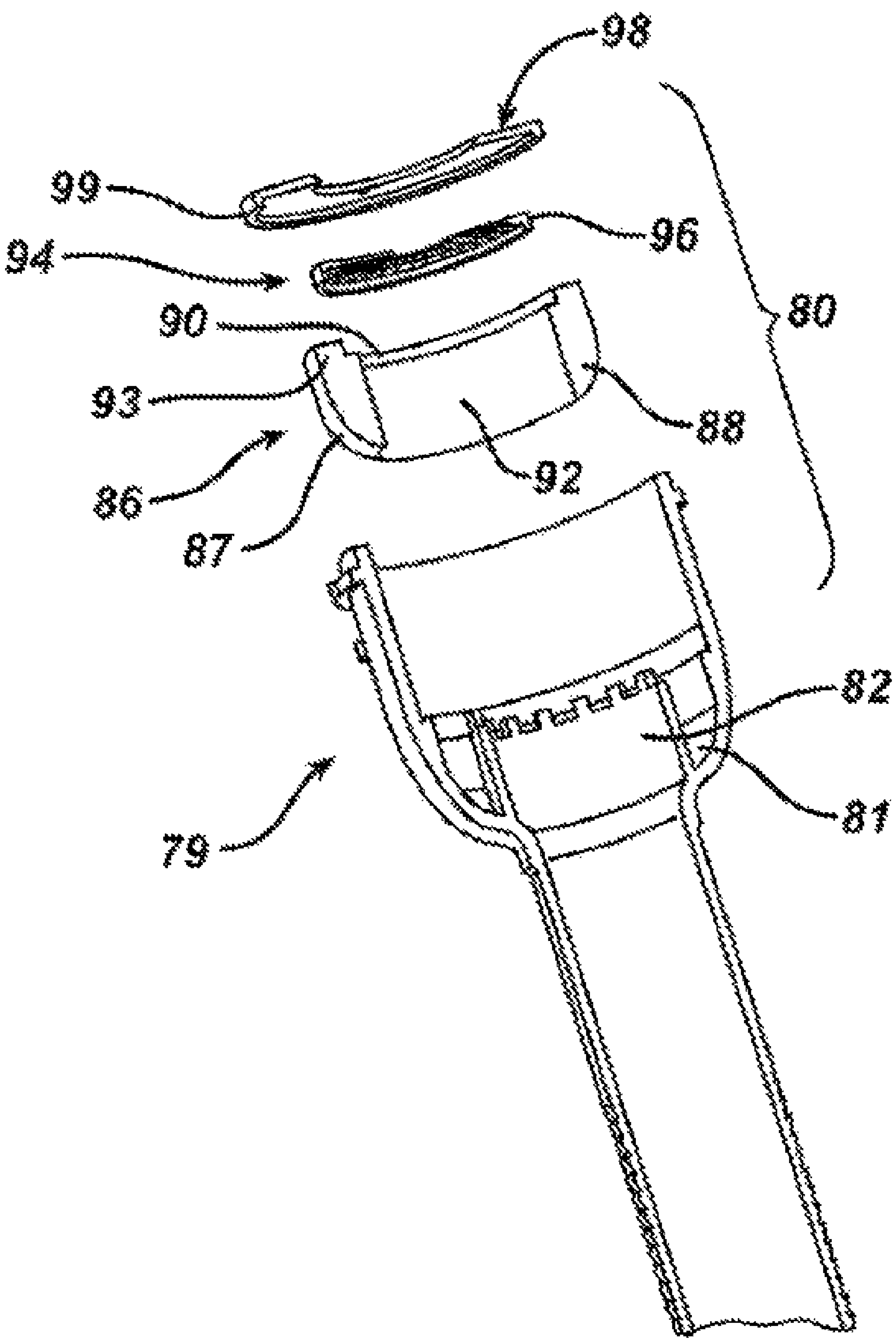


FIG. 3A

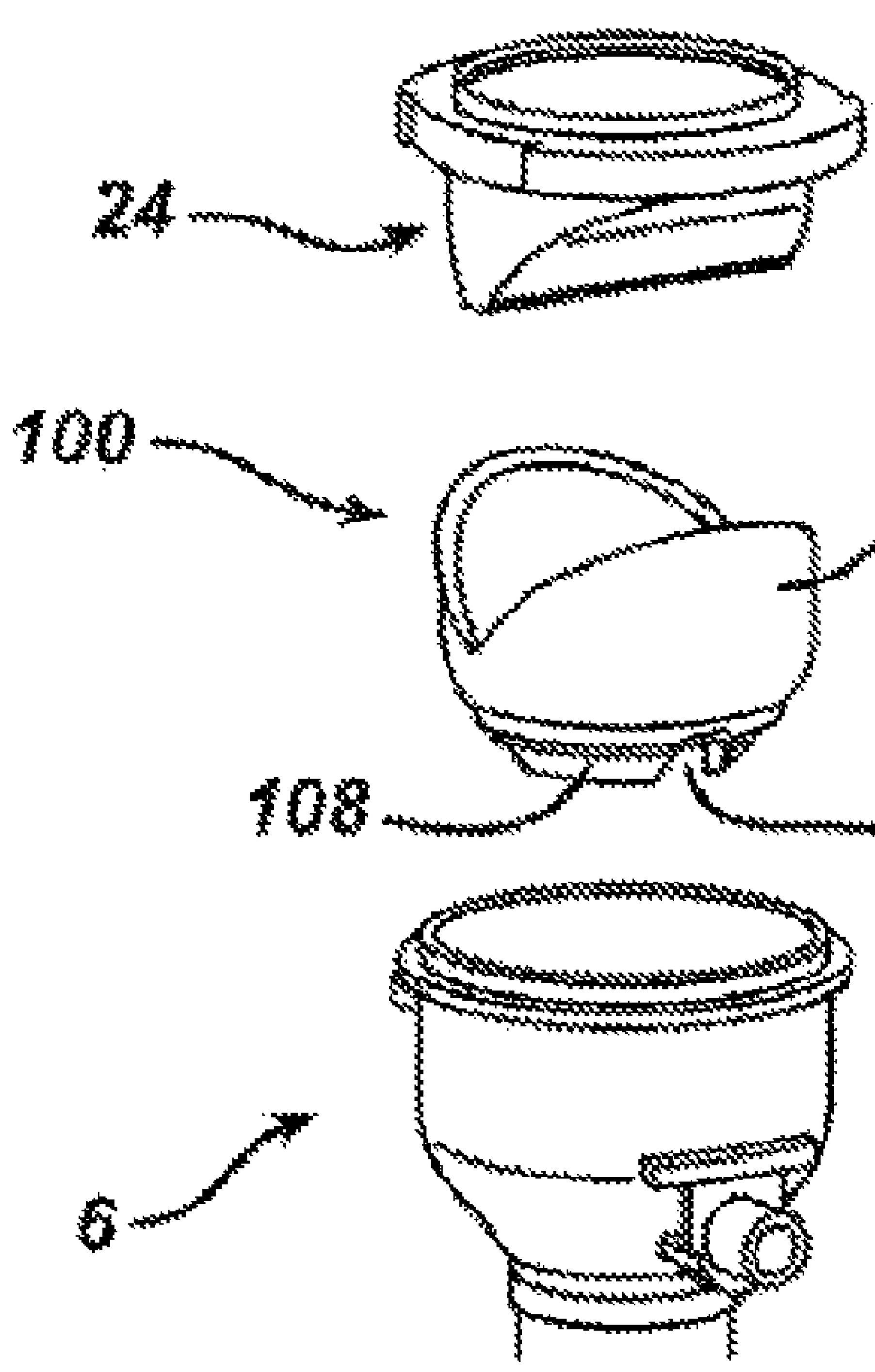


FIG. 3B

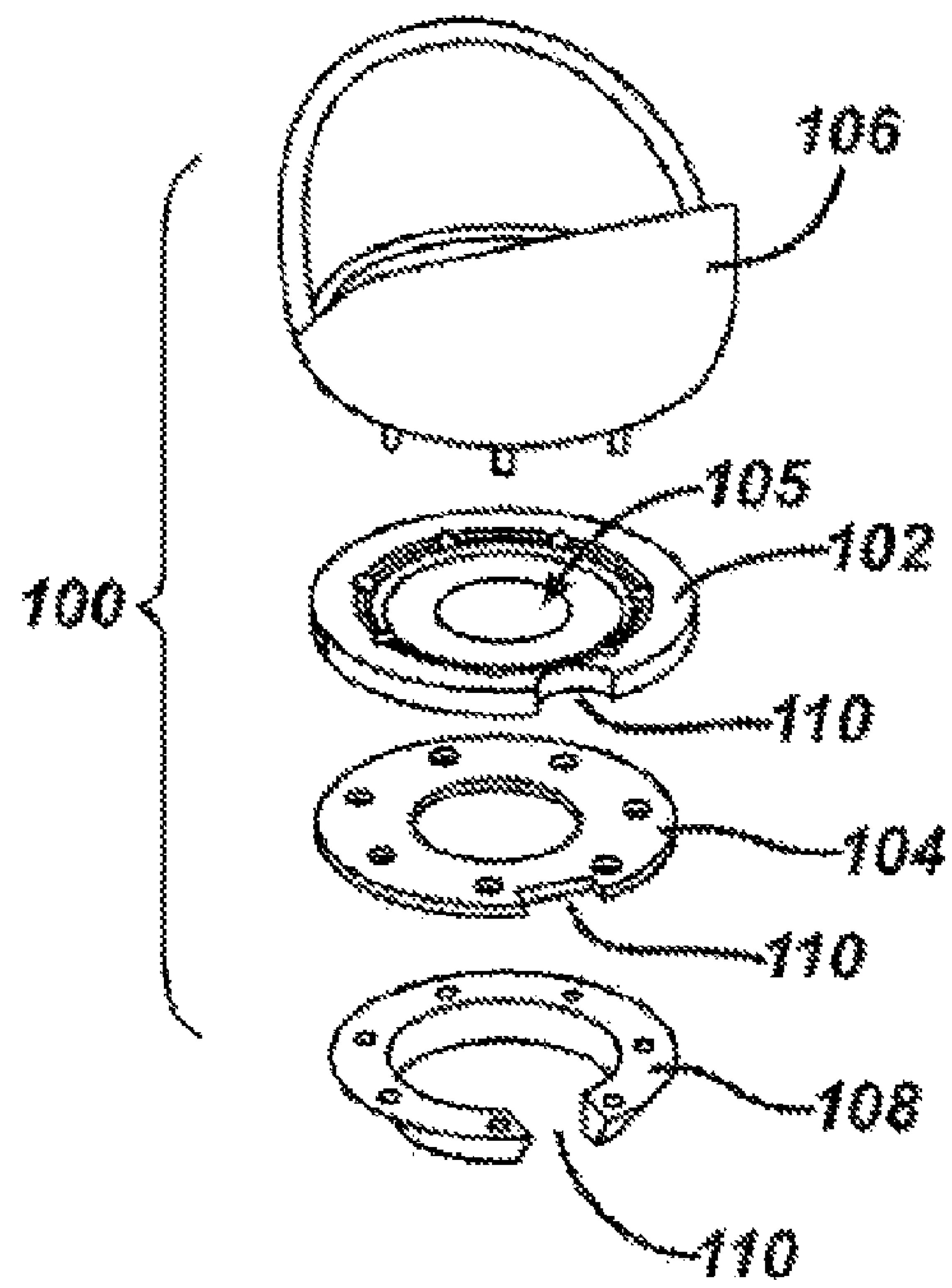


FIG. 3C

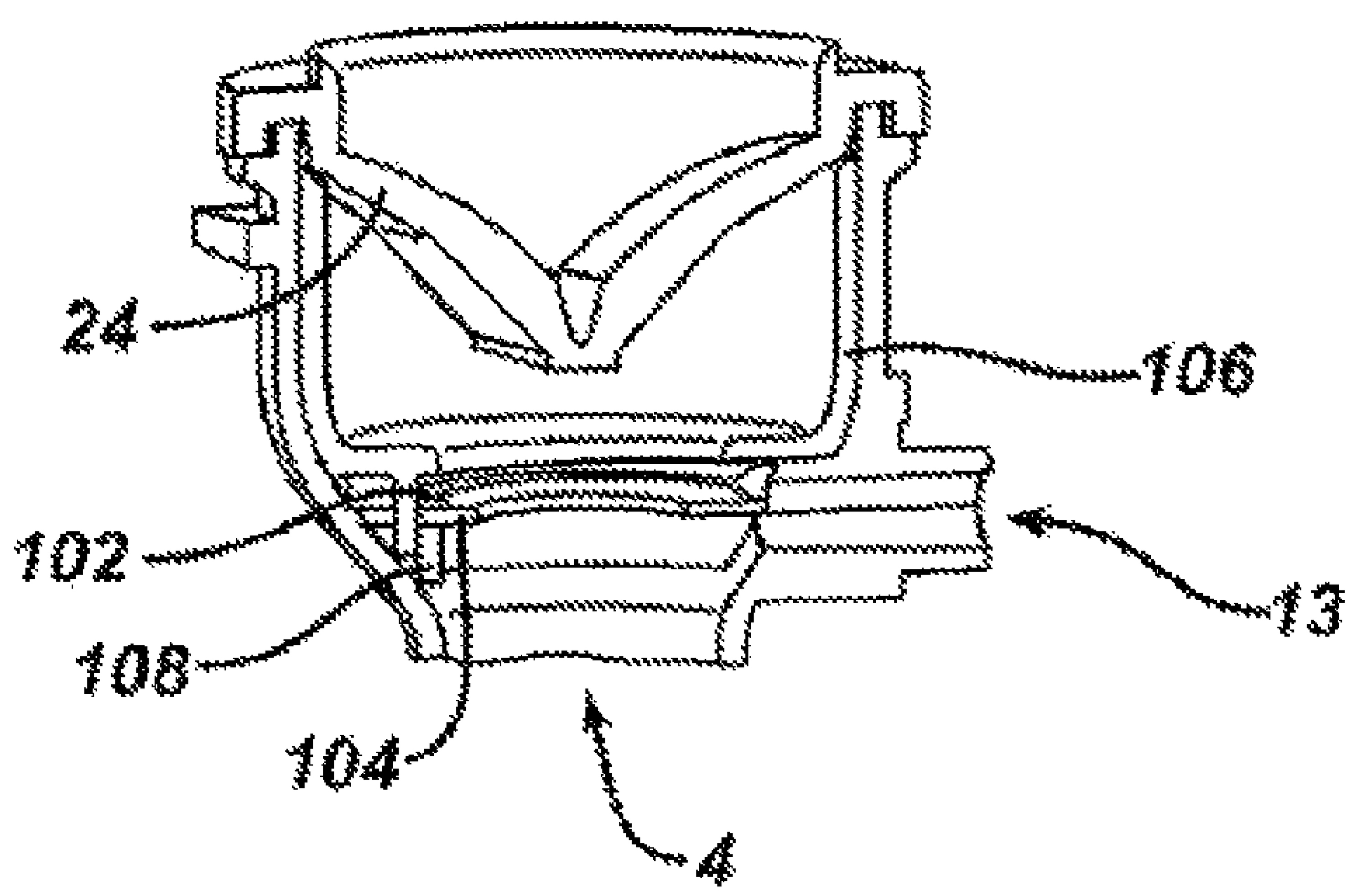


FIG. 4A

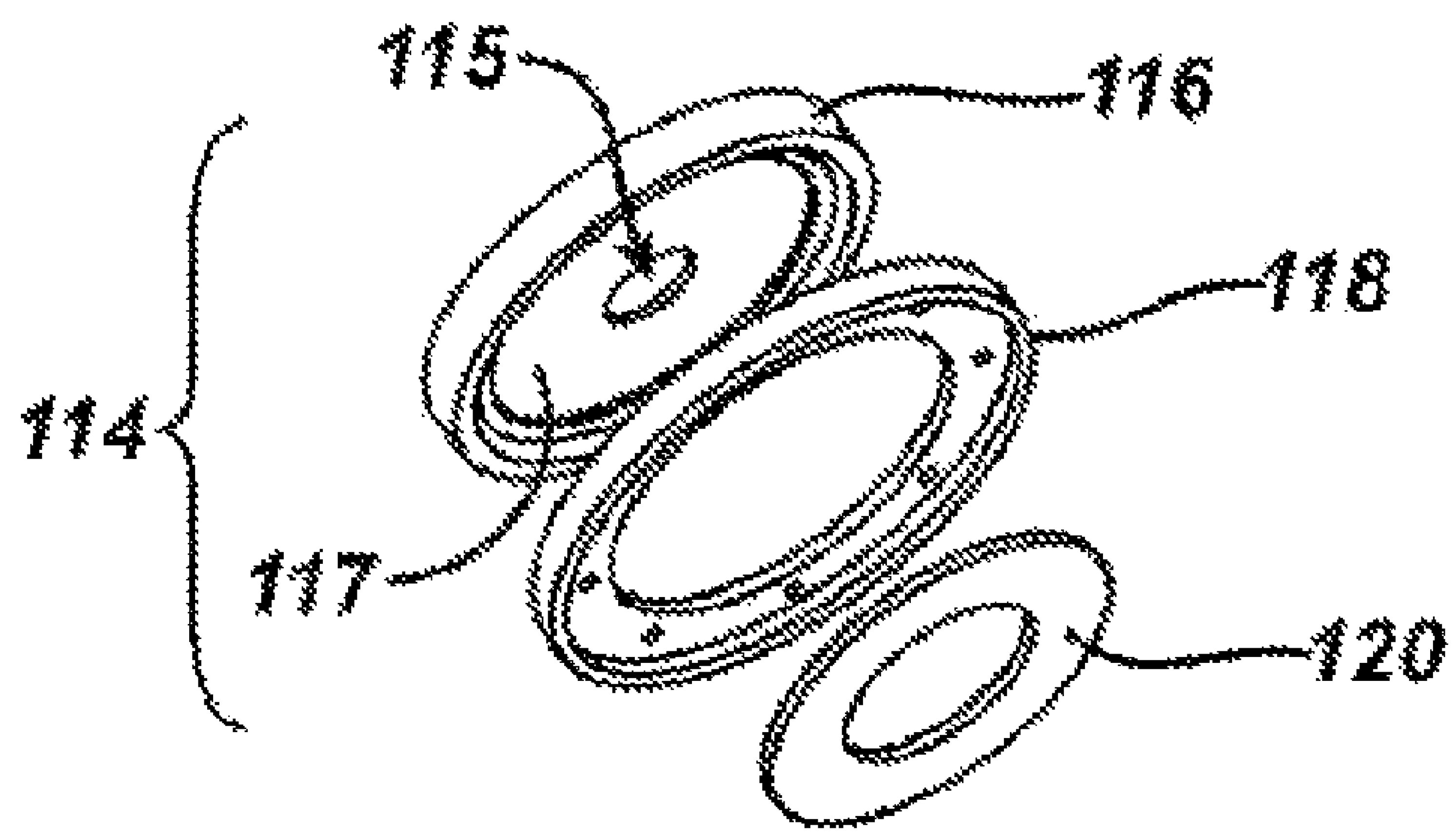


FIG. 4B

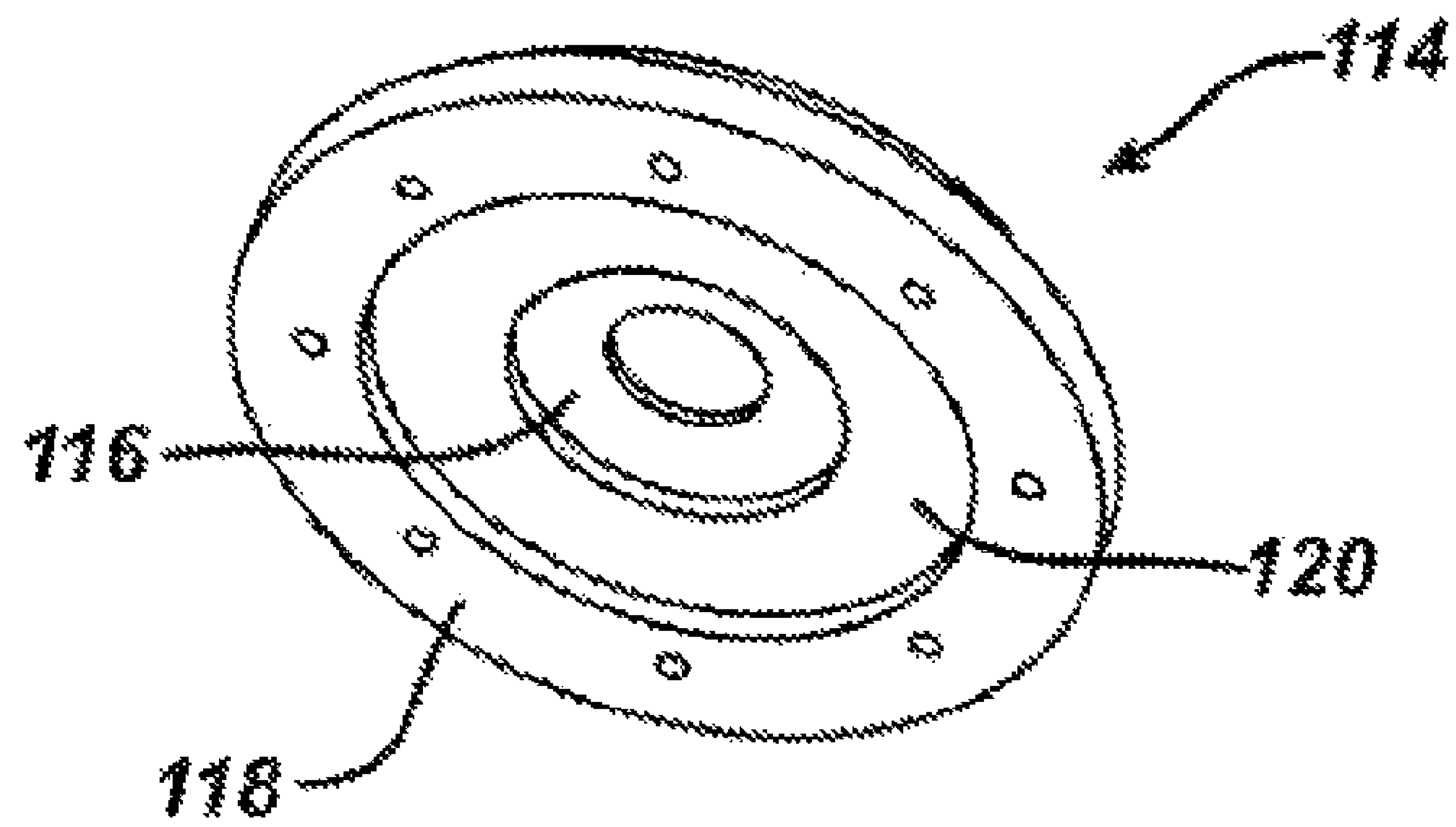


FIG. 4C

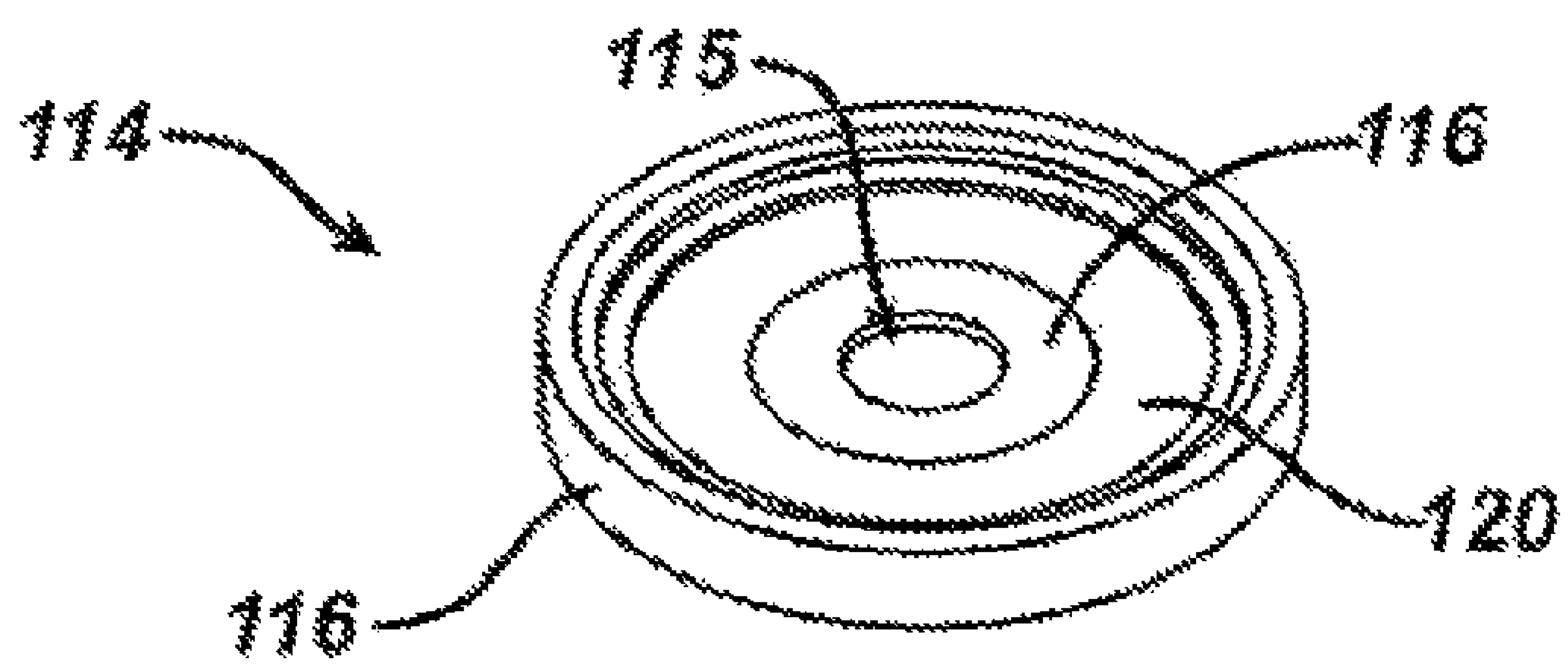


FIG. 5A

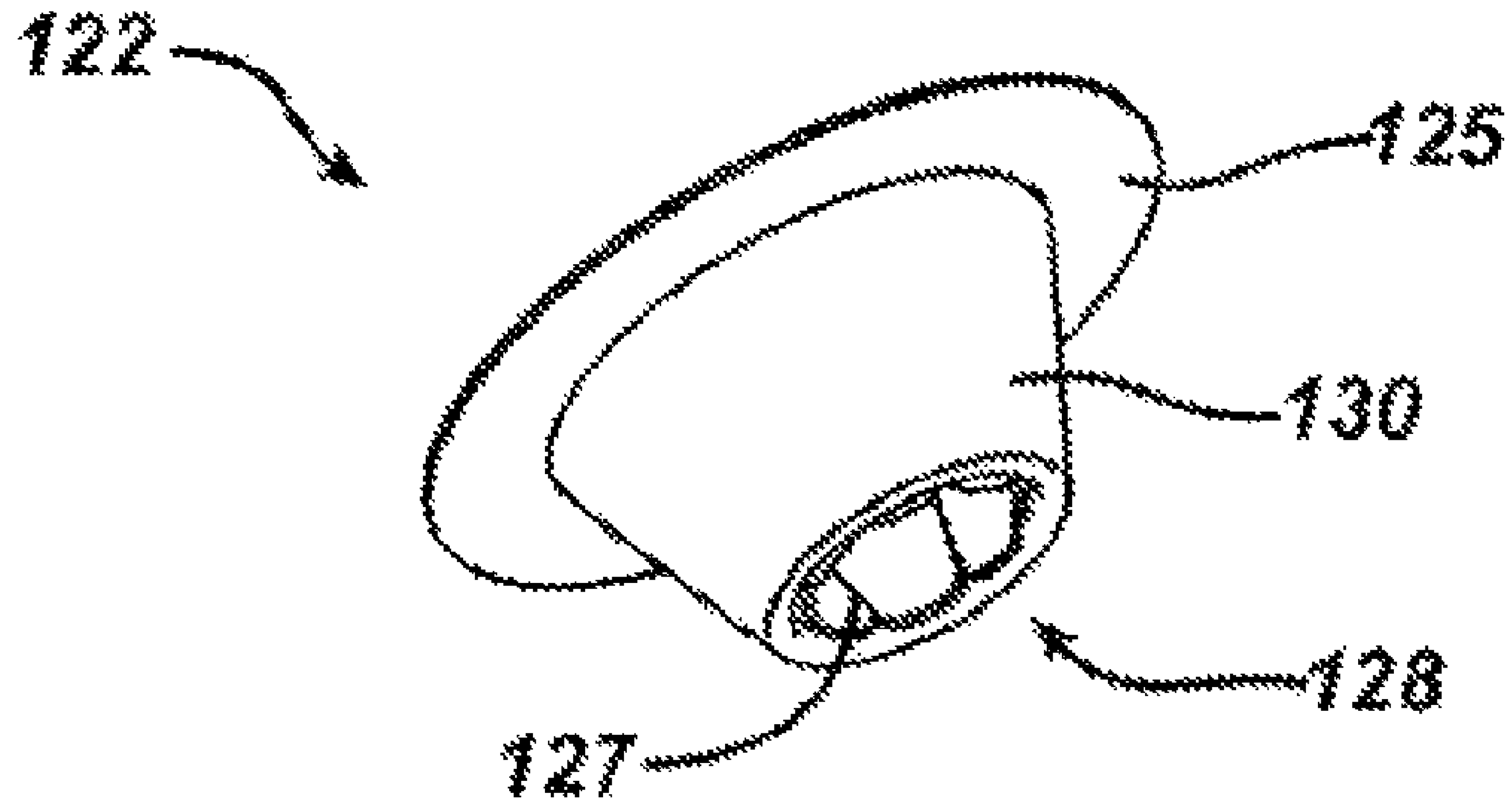


FIG. 5B

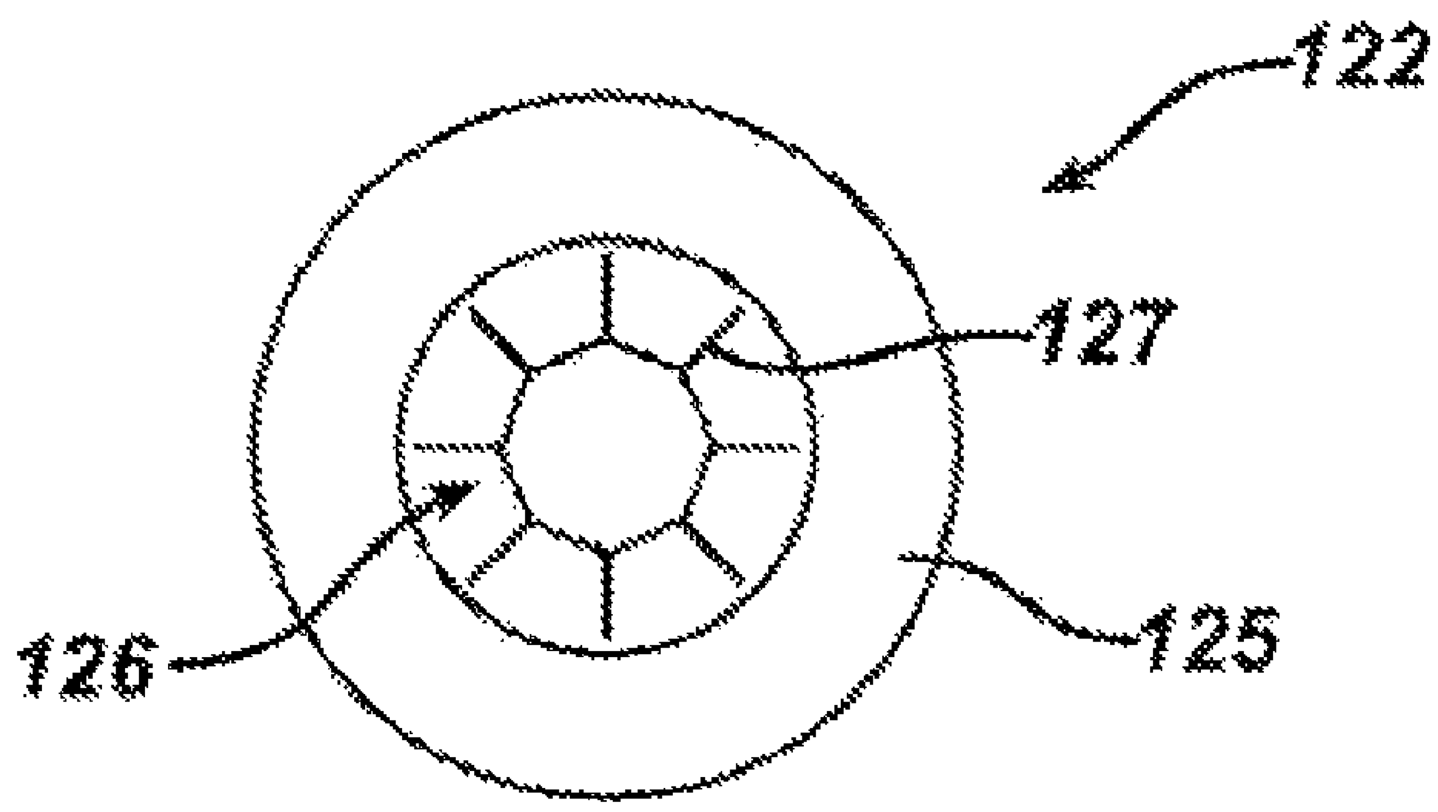
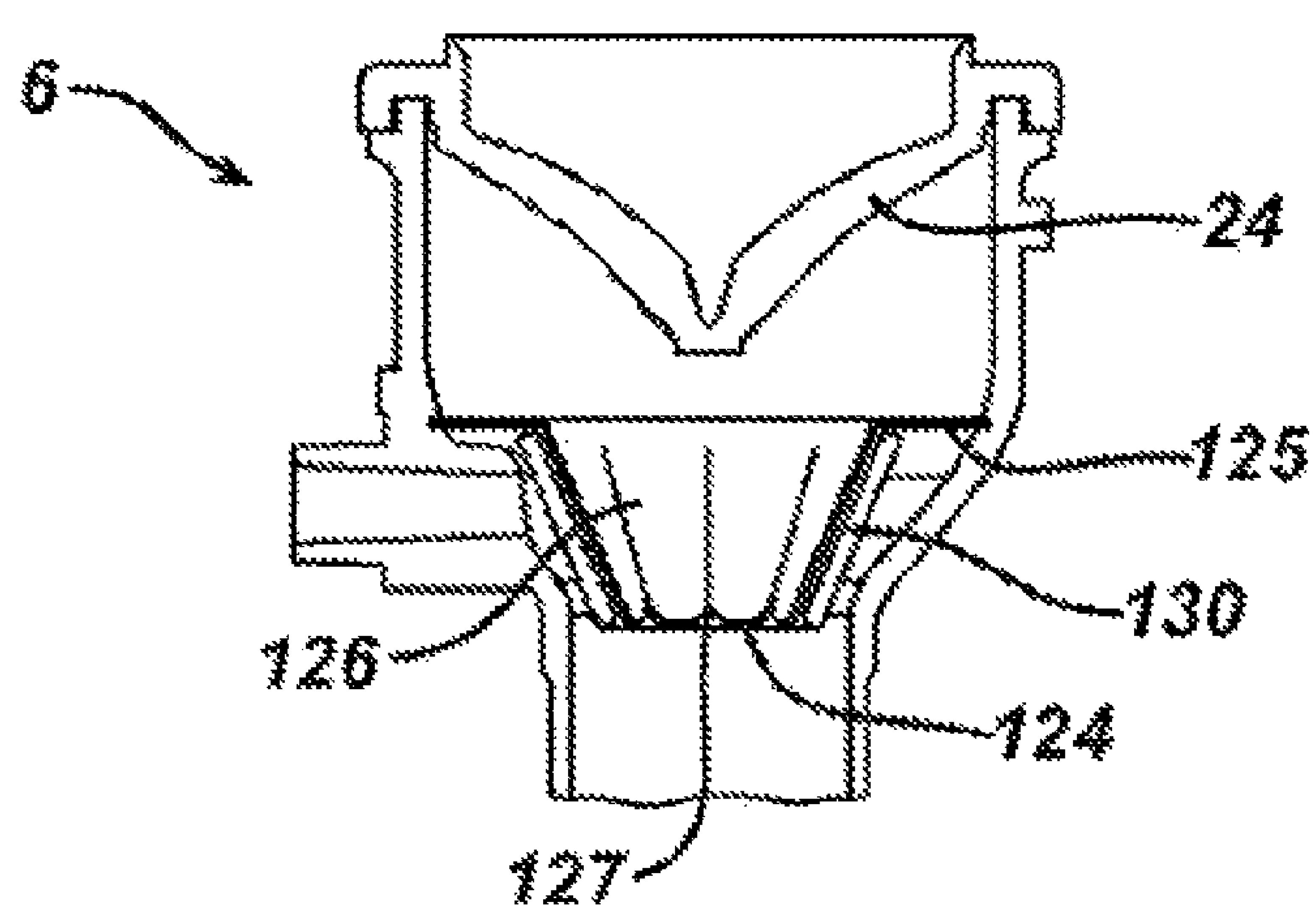


FIG. 5C



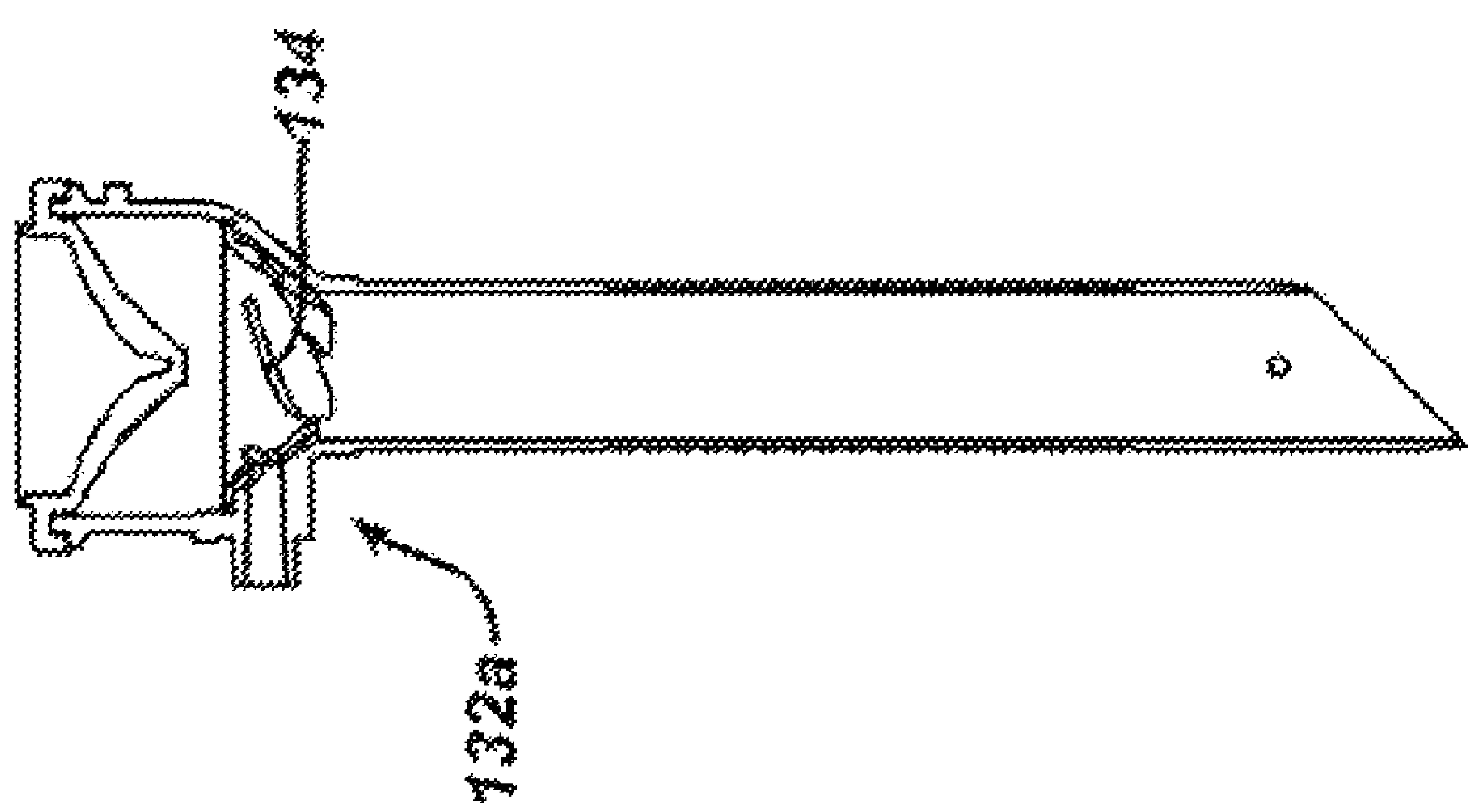


FIG. 6A

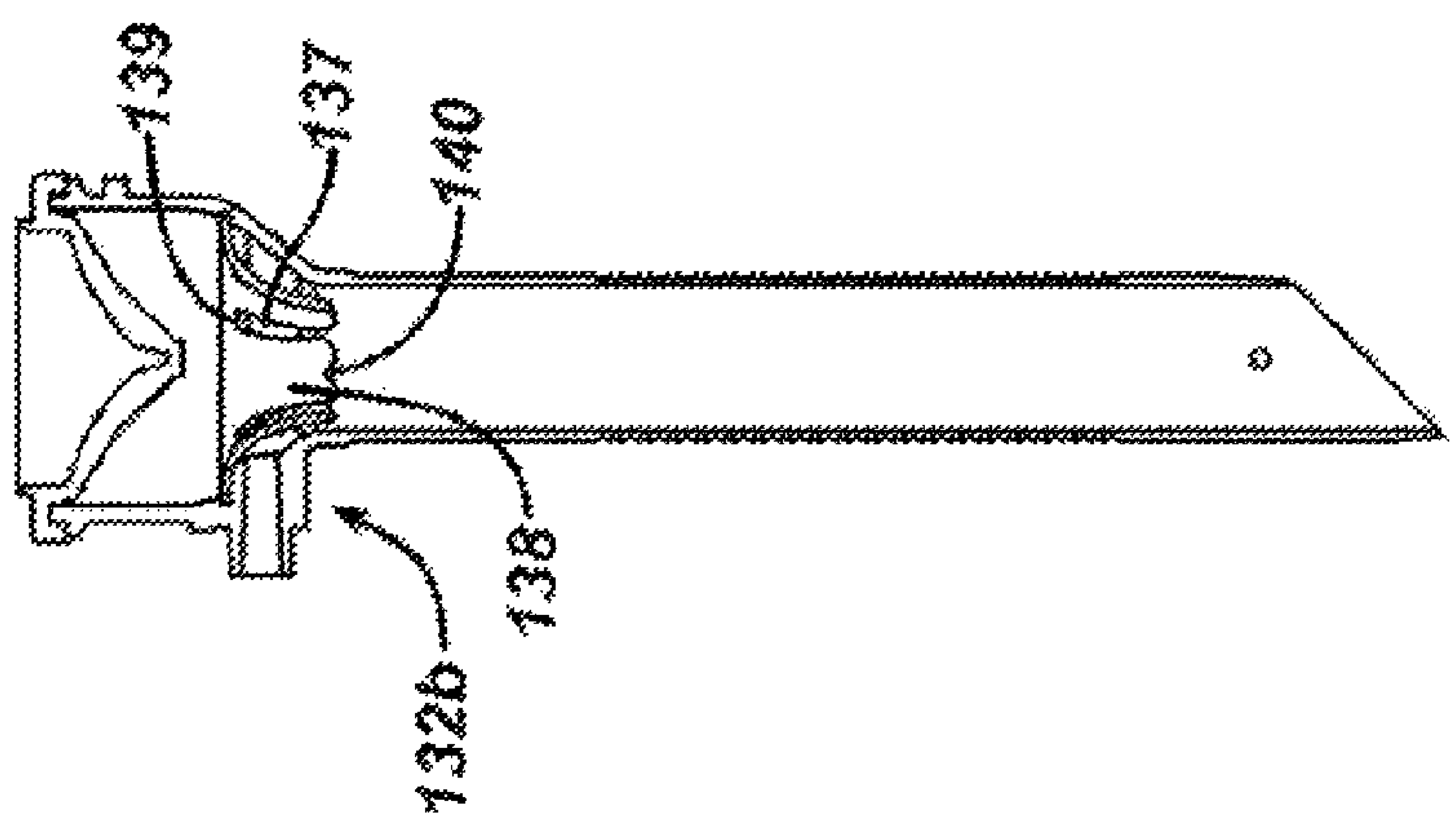


FIG. 6B

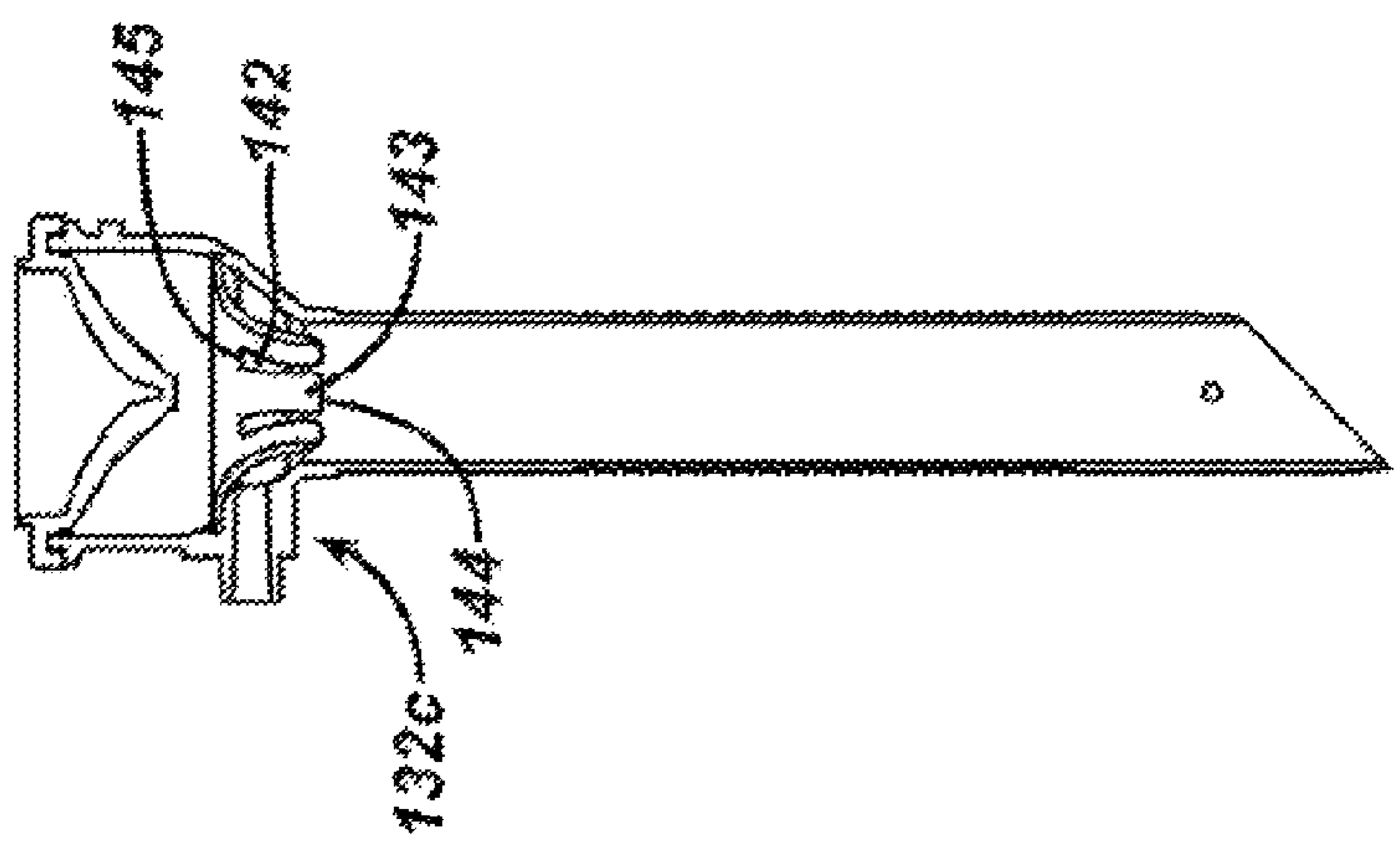


FIG. 6C

FIG. 7

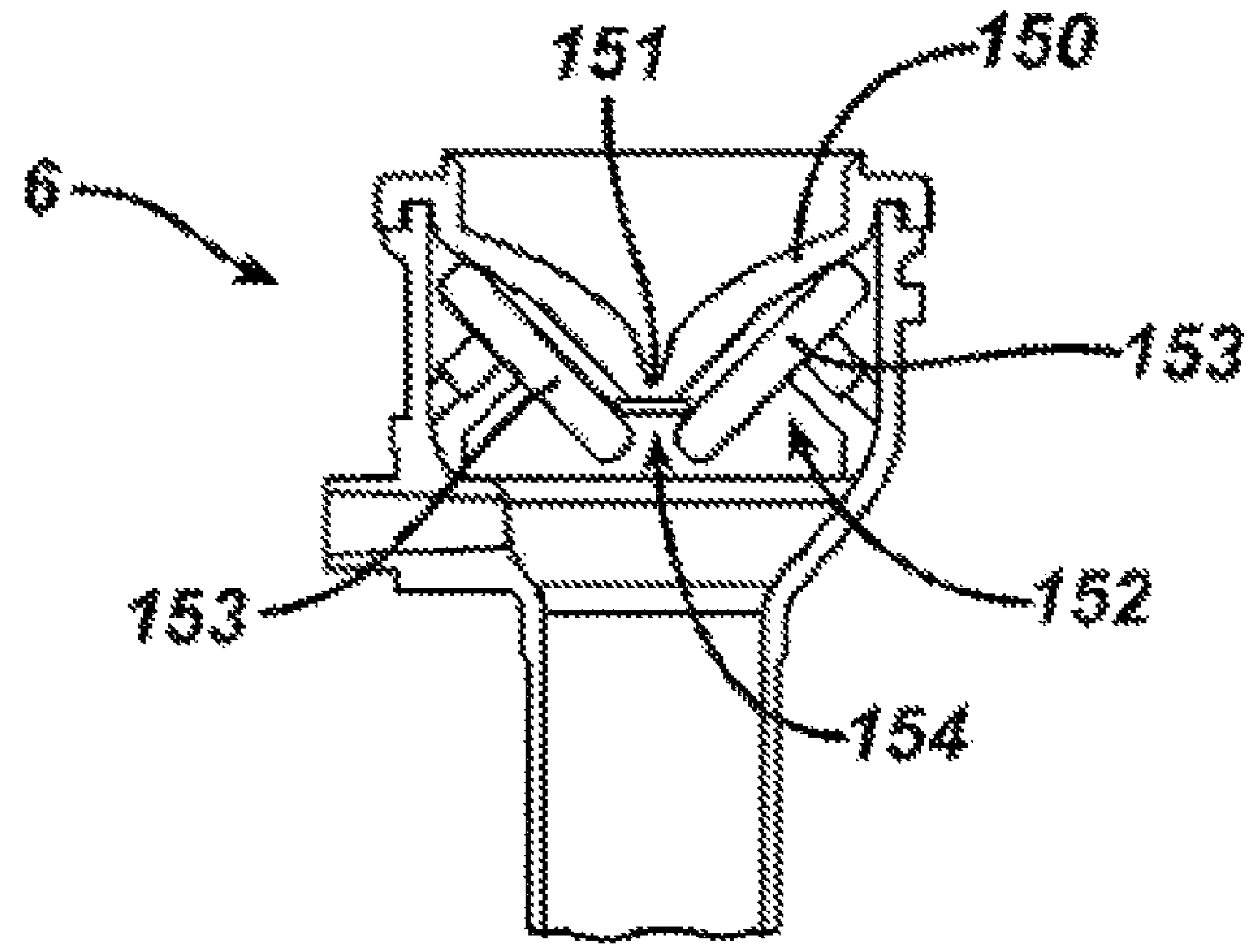


FIG. 8

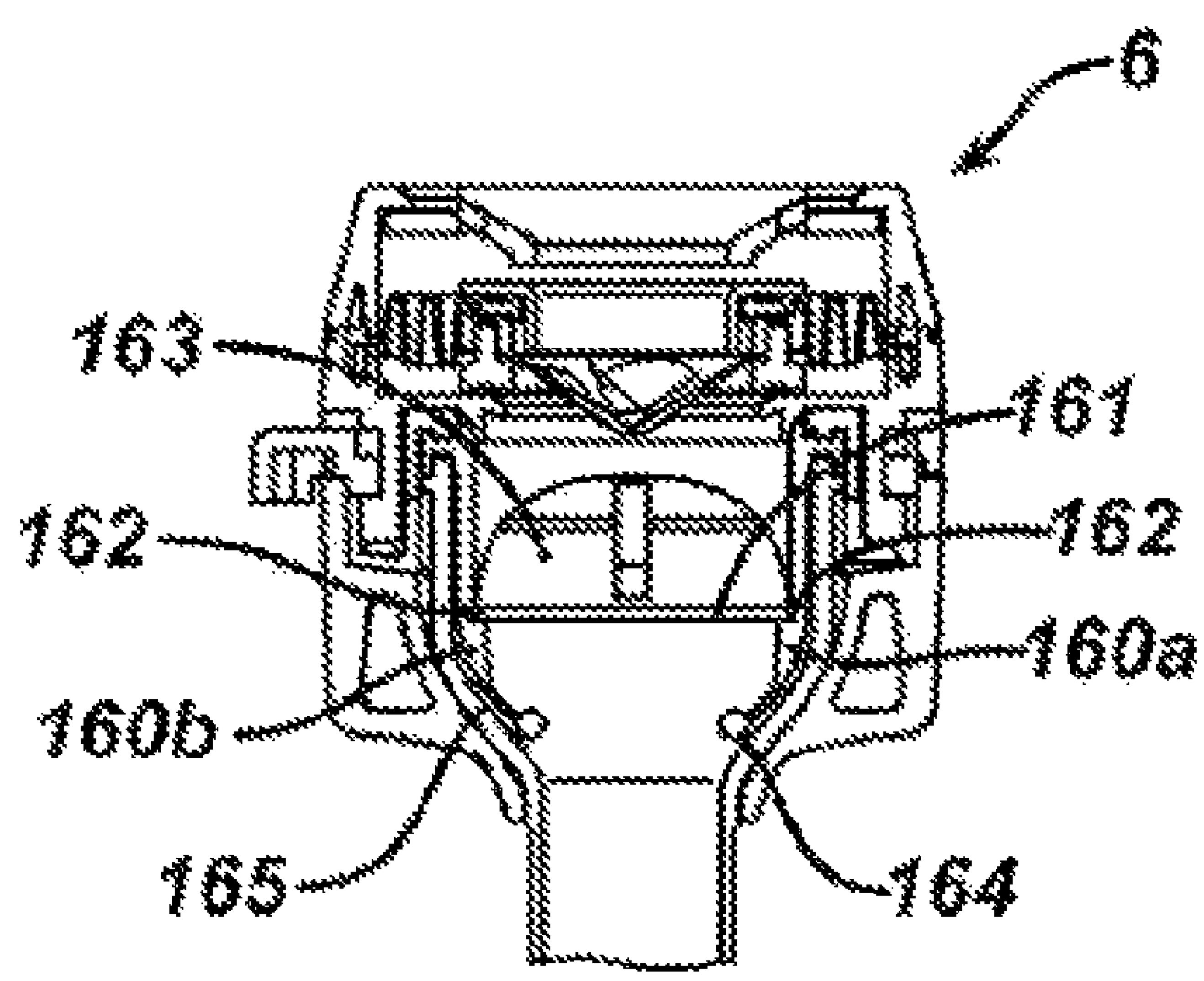


FIG. 9

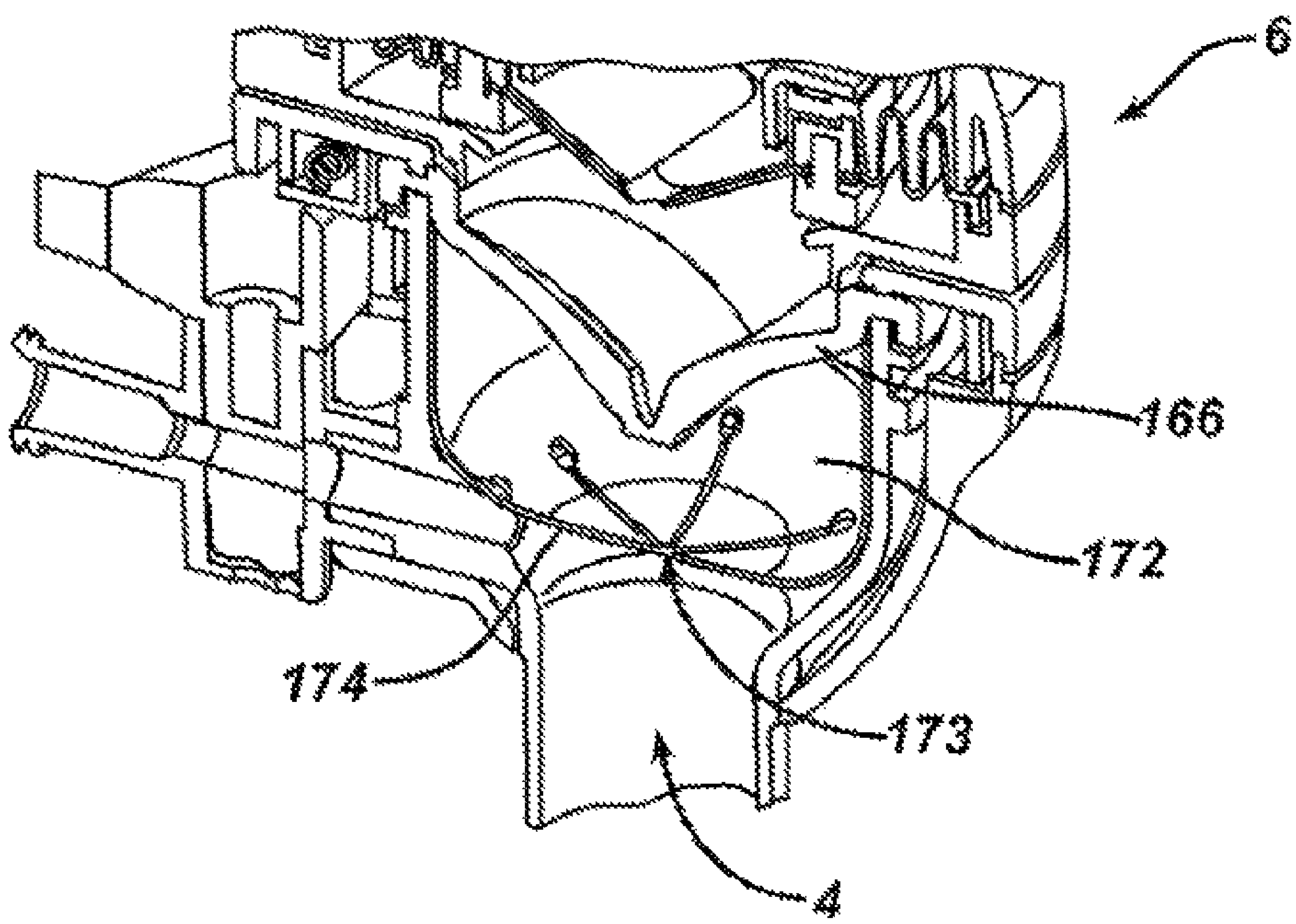


FIG. 10A

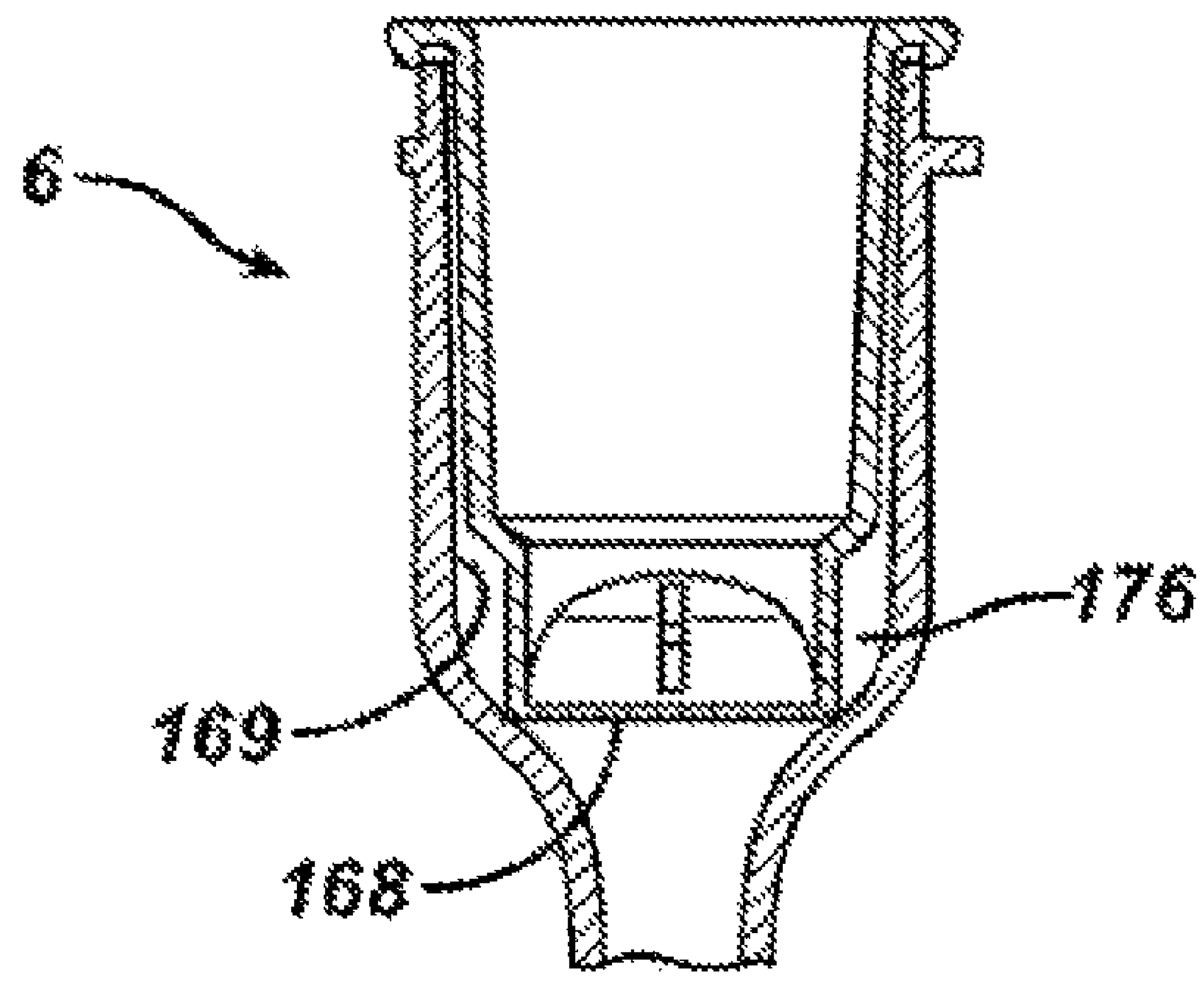


FIG. 10B

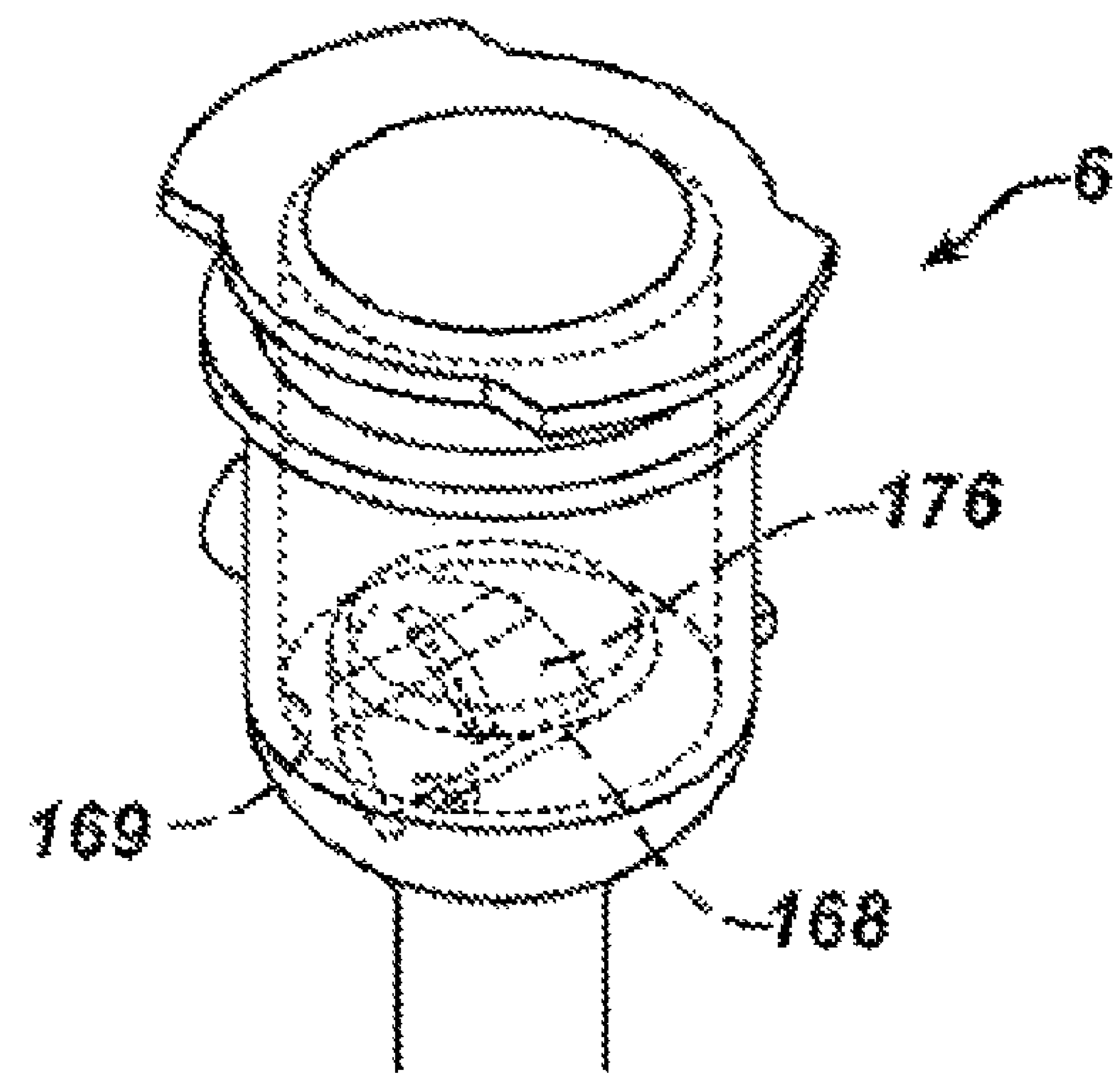


FIG. 11

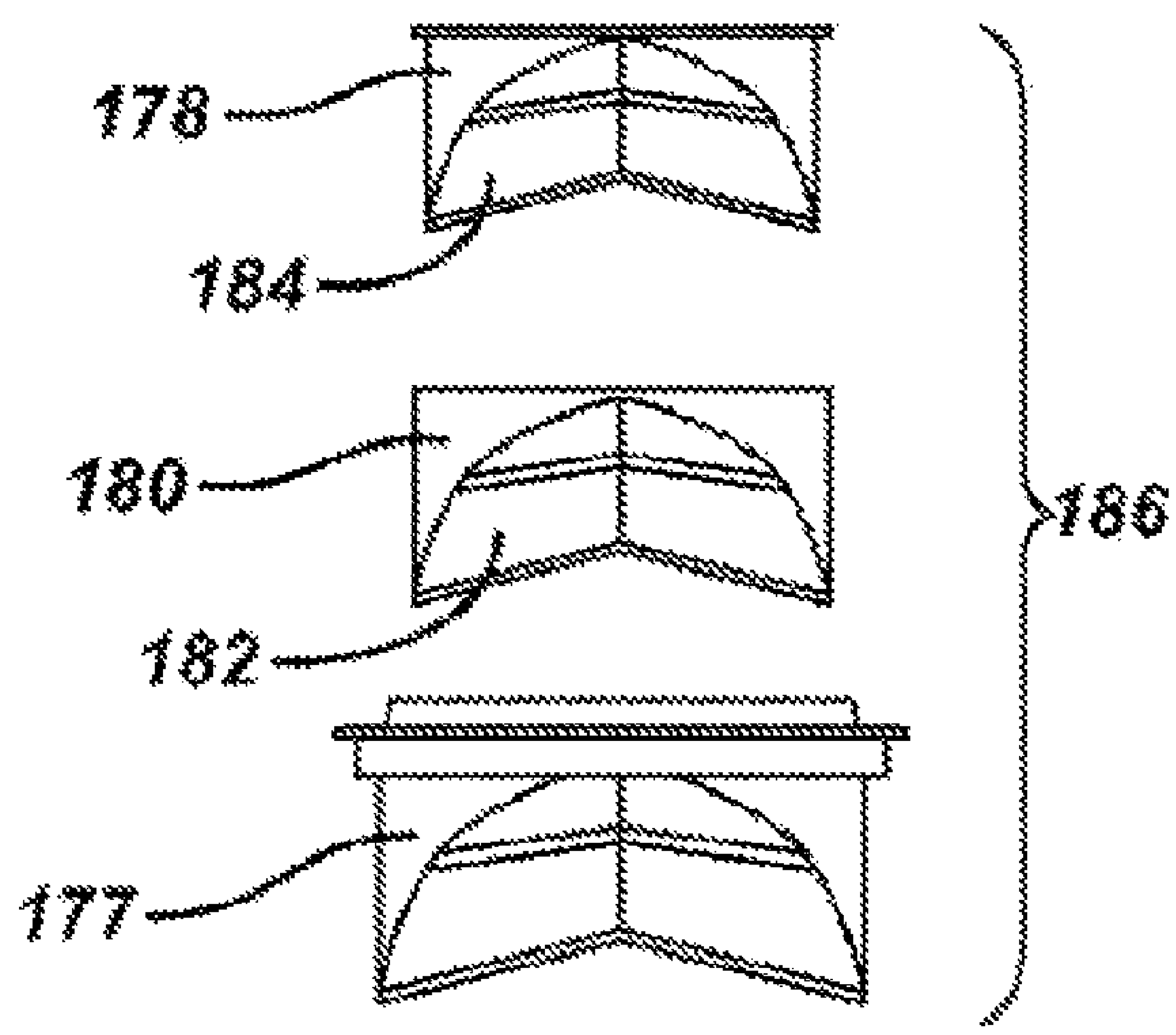


FIG. 12A

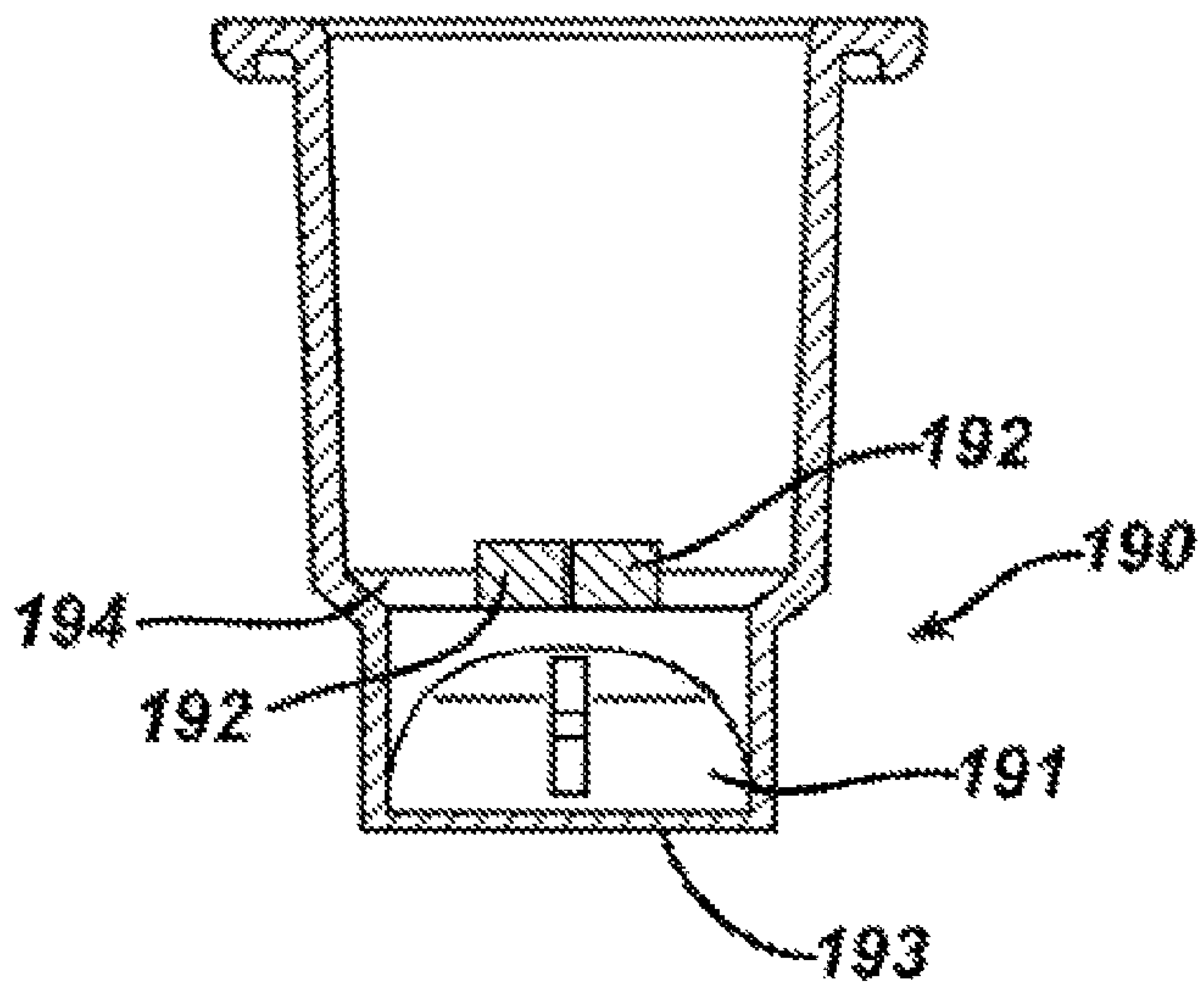


FIG. 12B

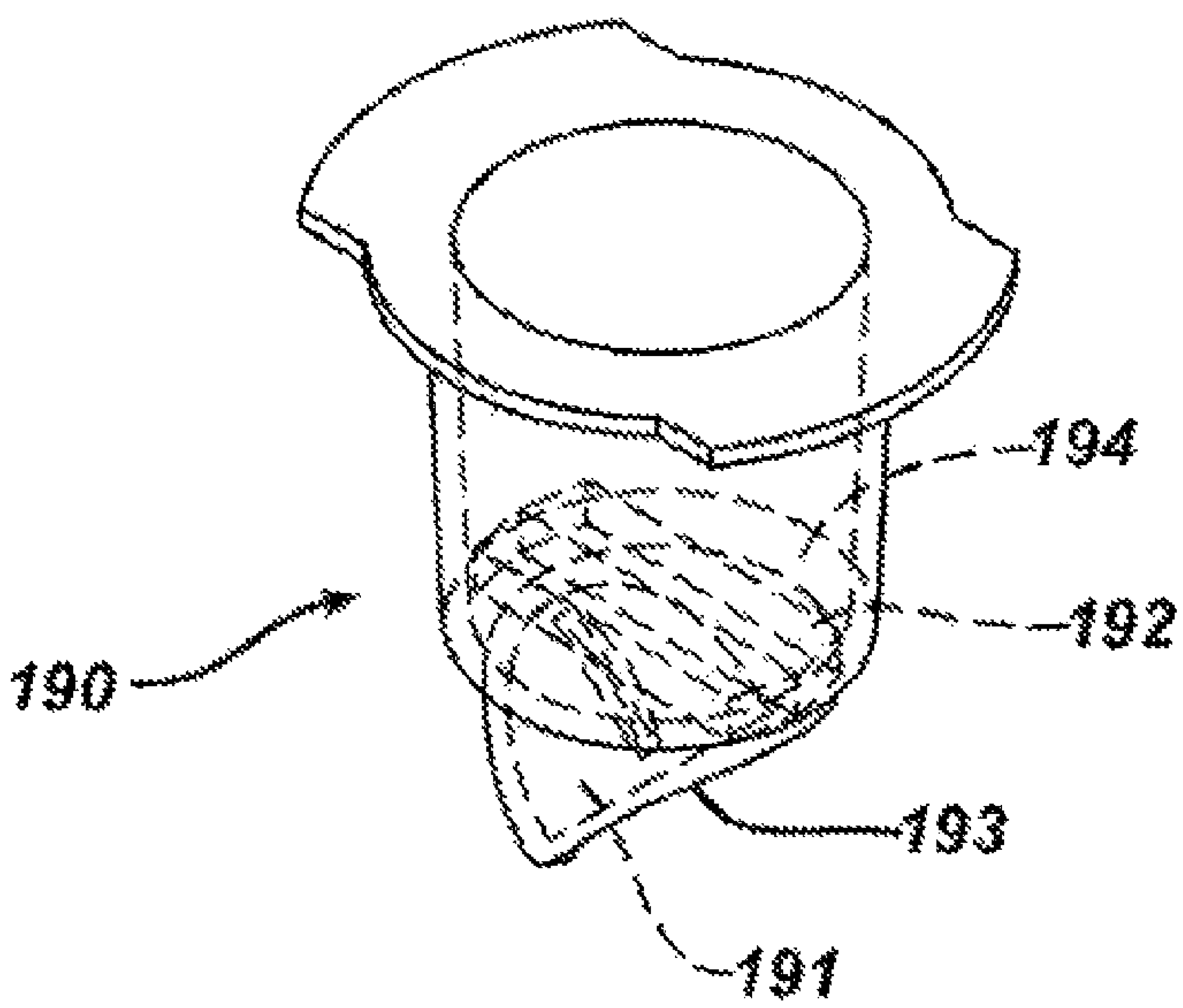


FIG. 13

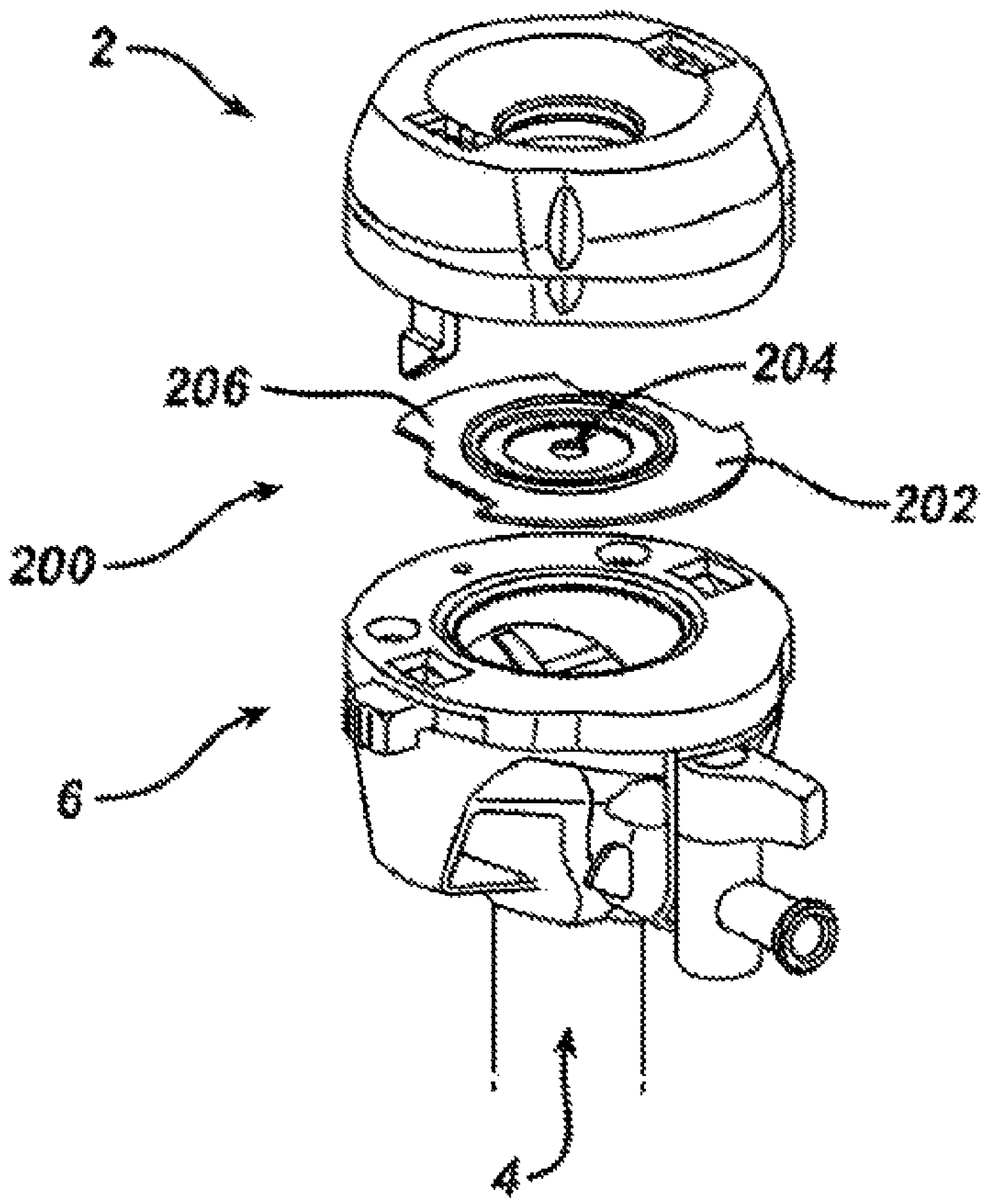


FIG. 14

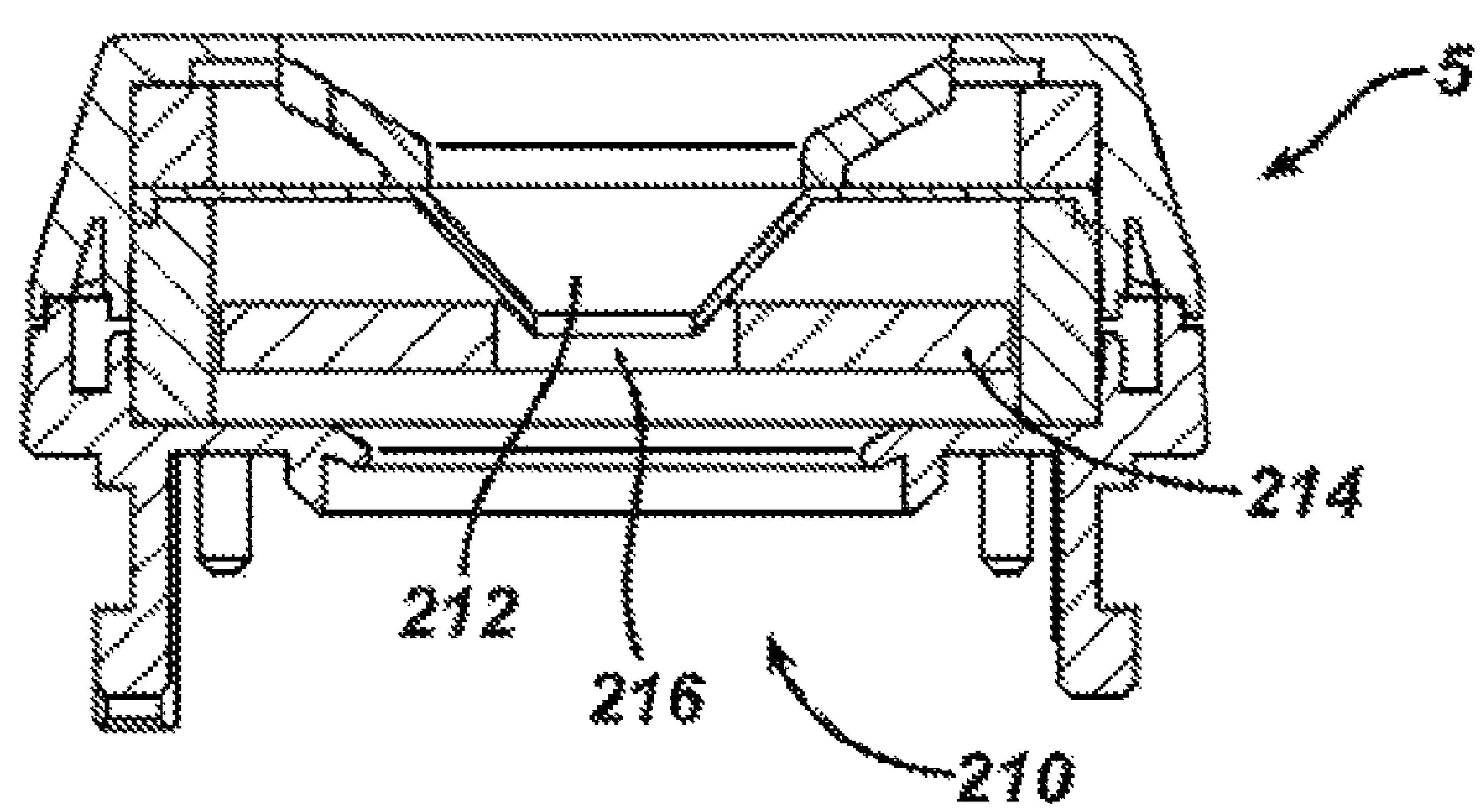


FIG. 15A

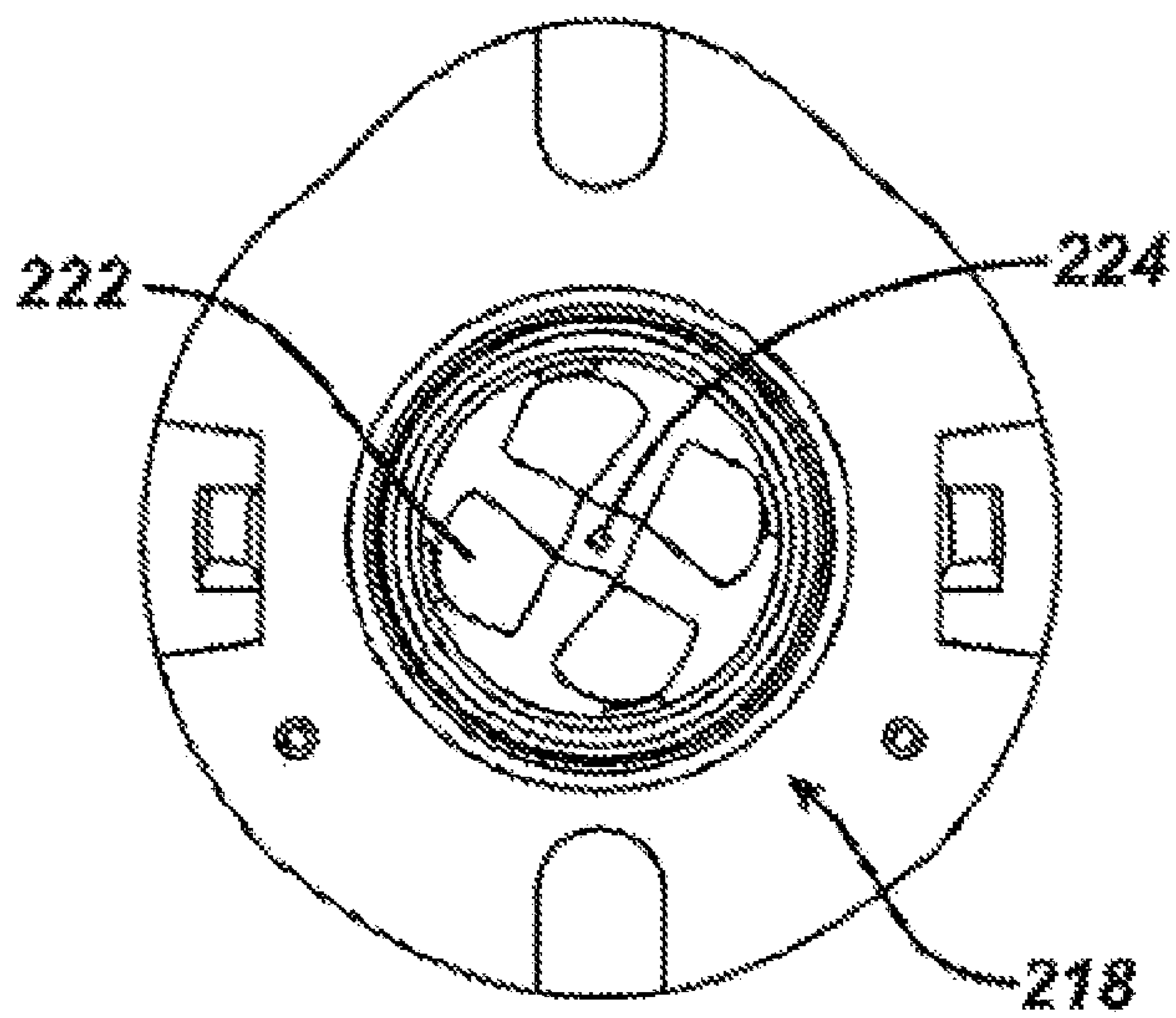


FIG. 15B

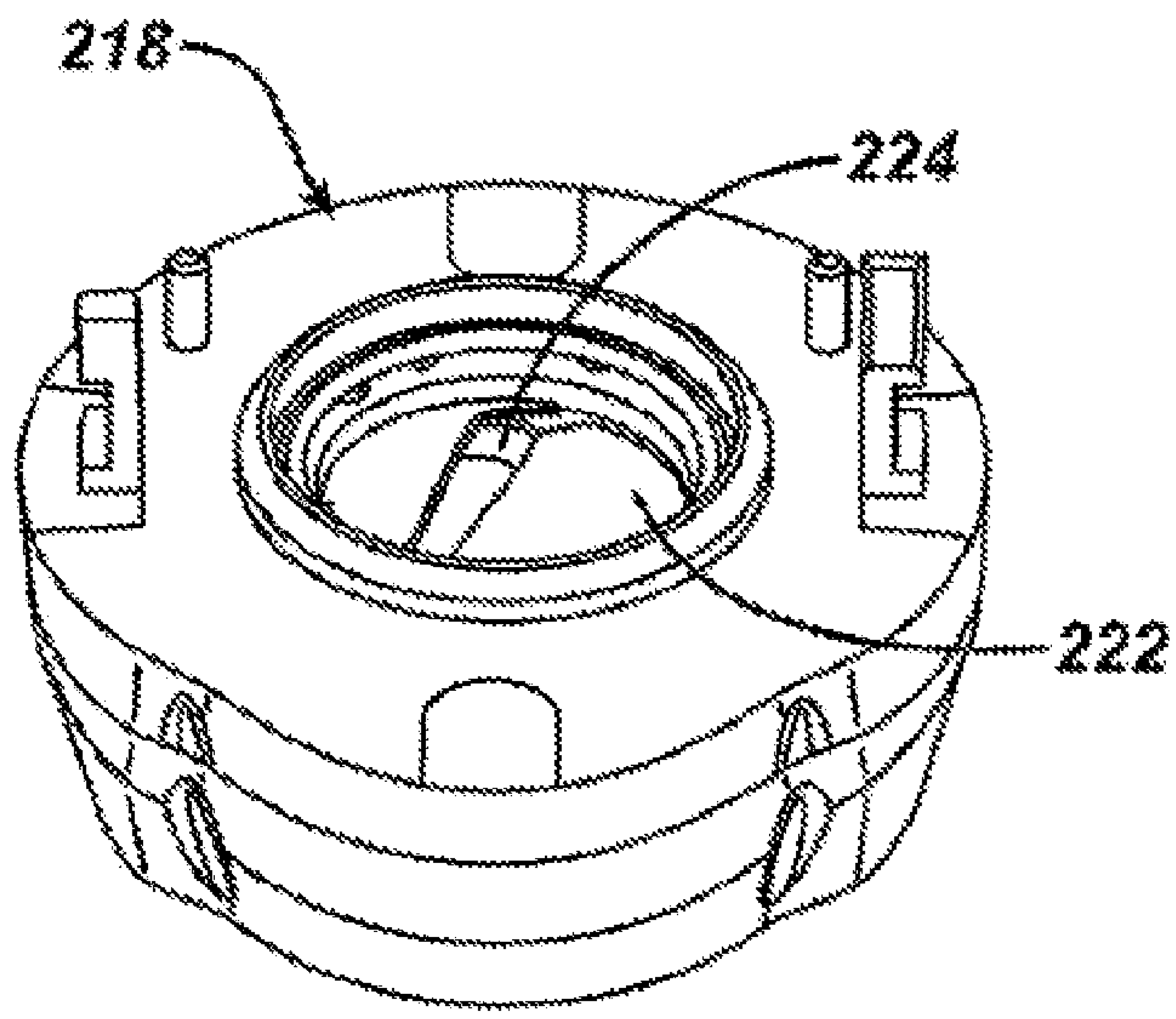


FIG. 16

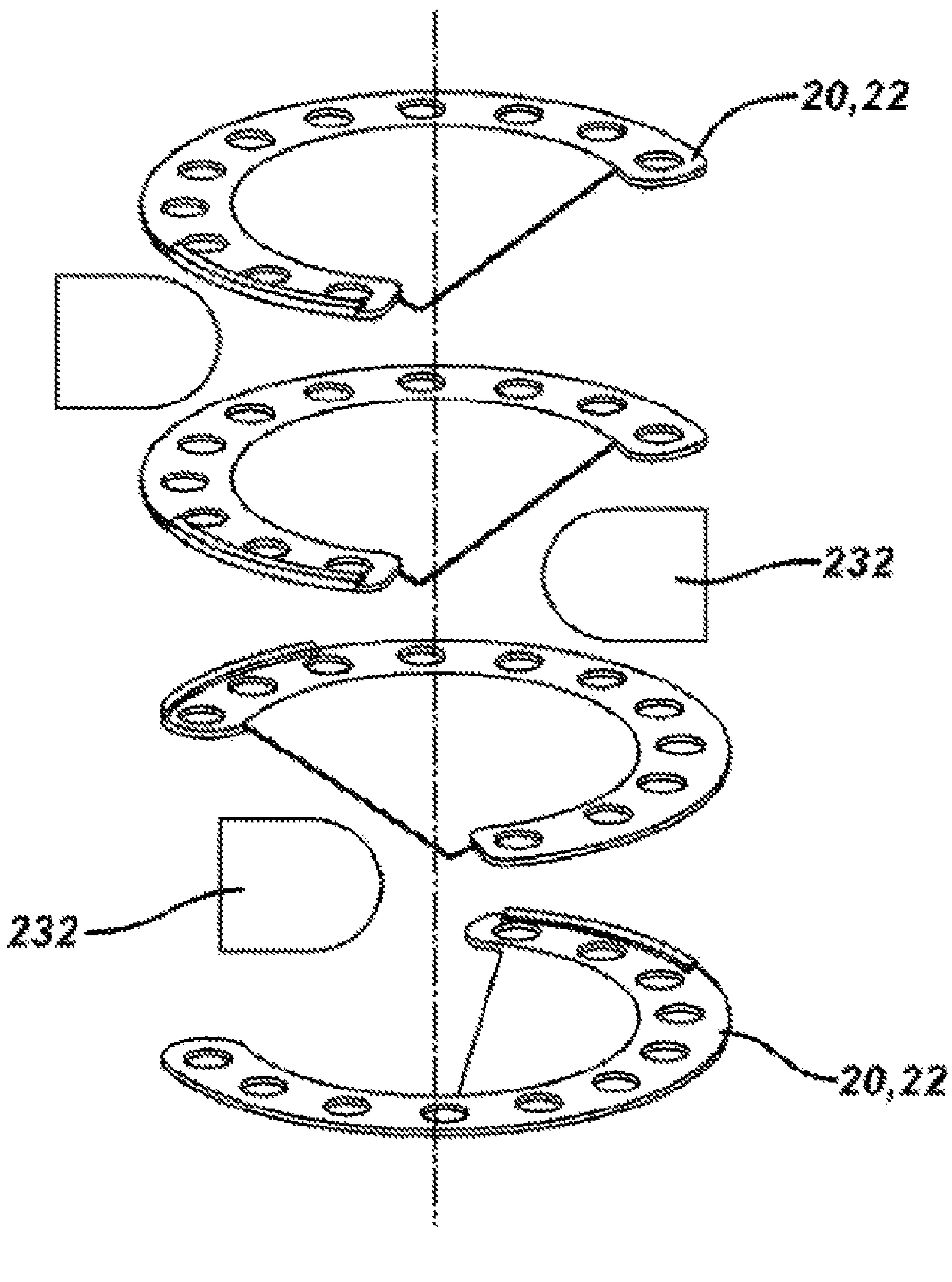


FIG. 17

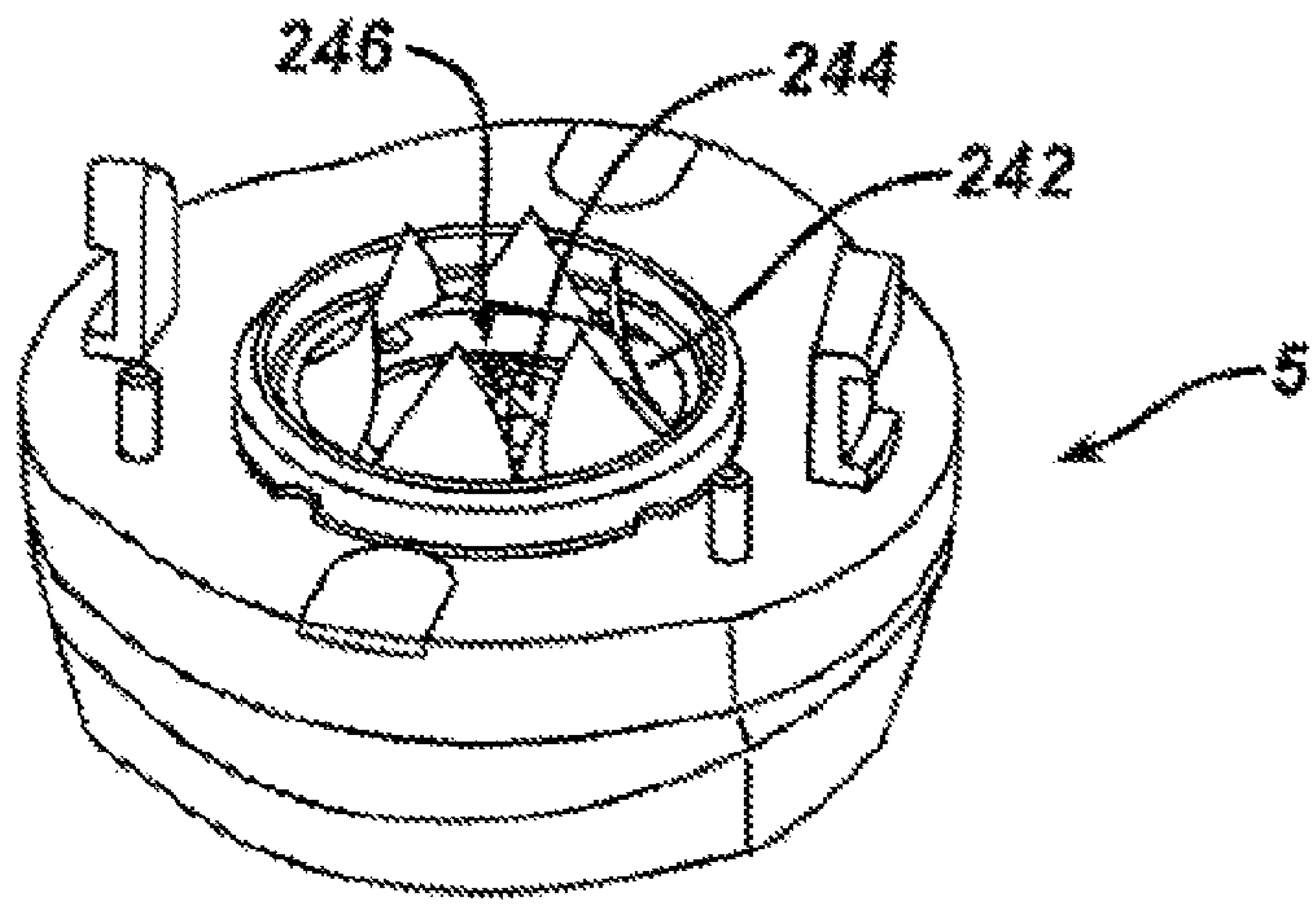


FIG. 18A

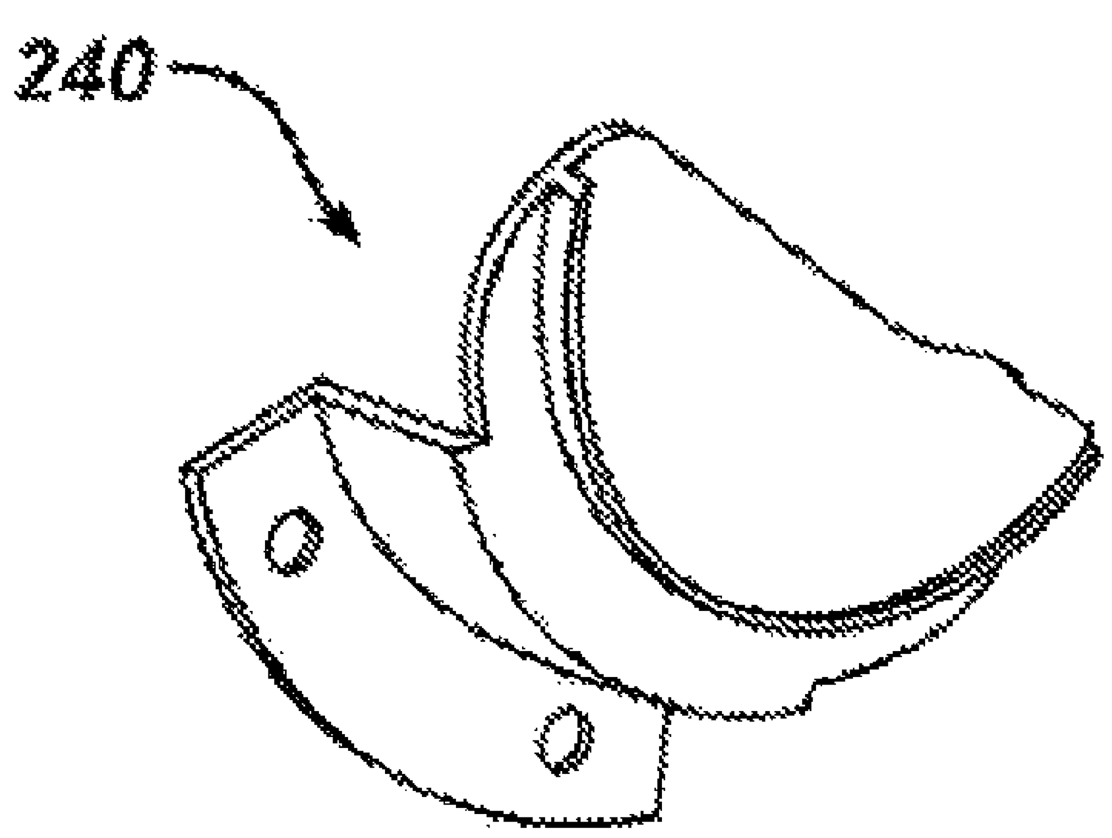


FIG. 18B

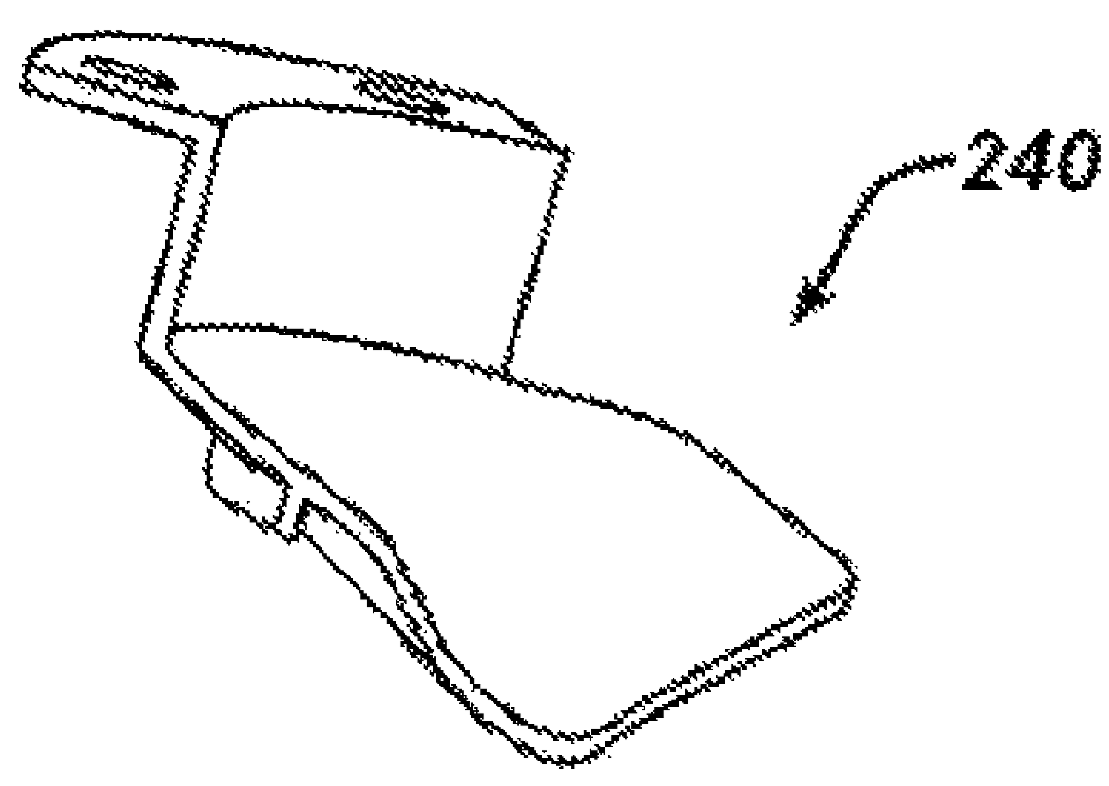


FIG. 19A

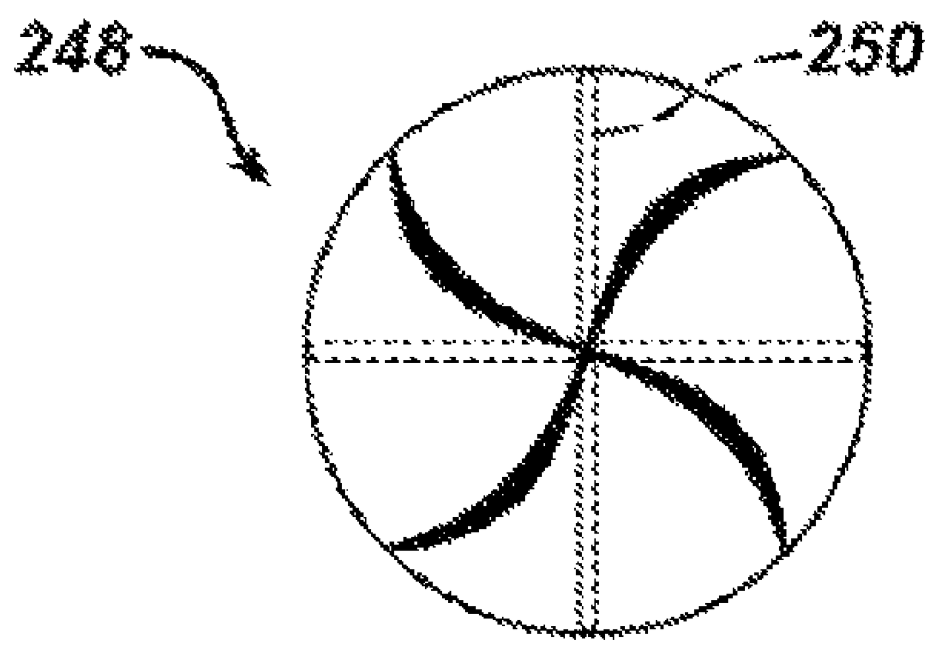


FIG. 19B

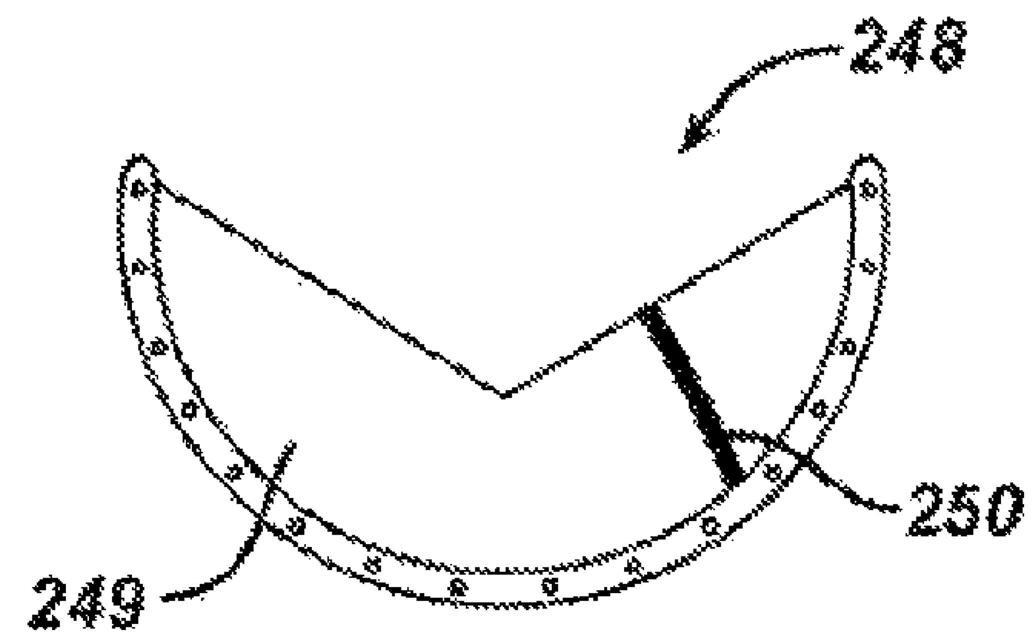


FIG. 20A

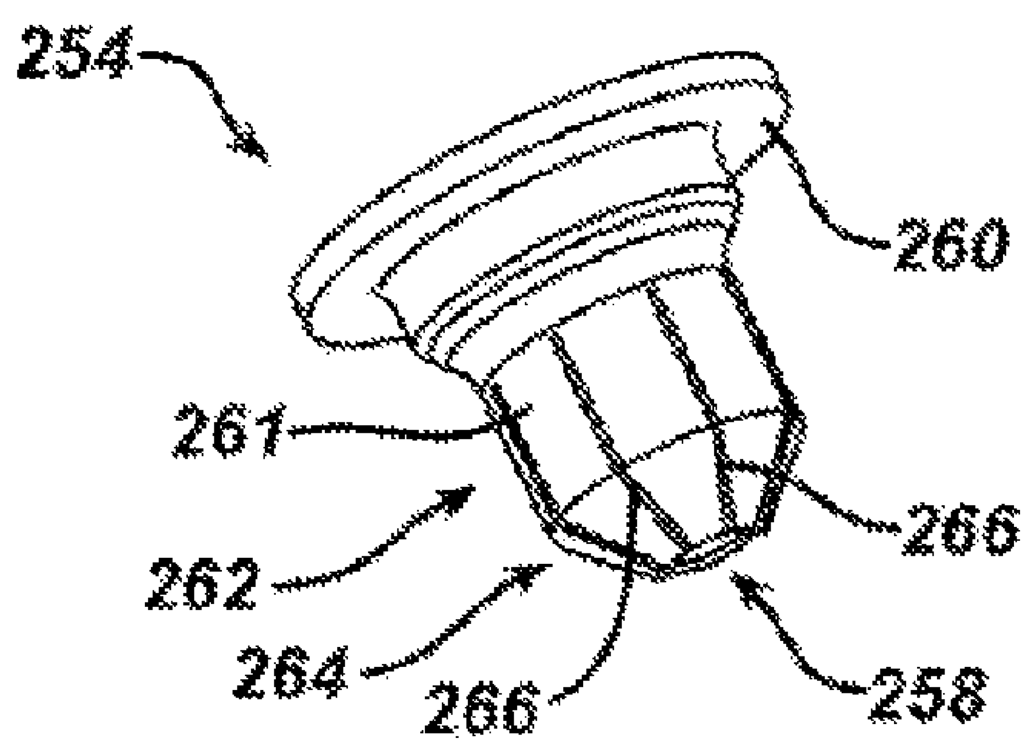


FIG. 20B

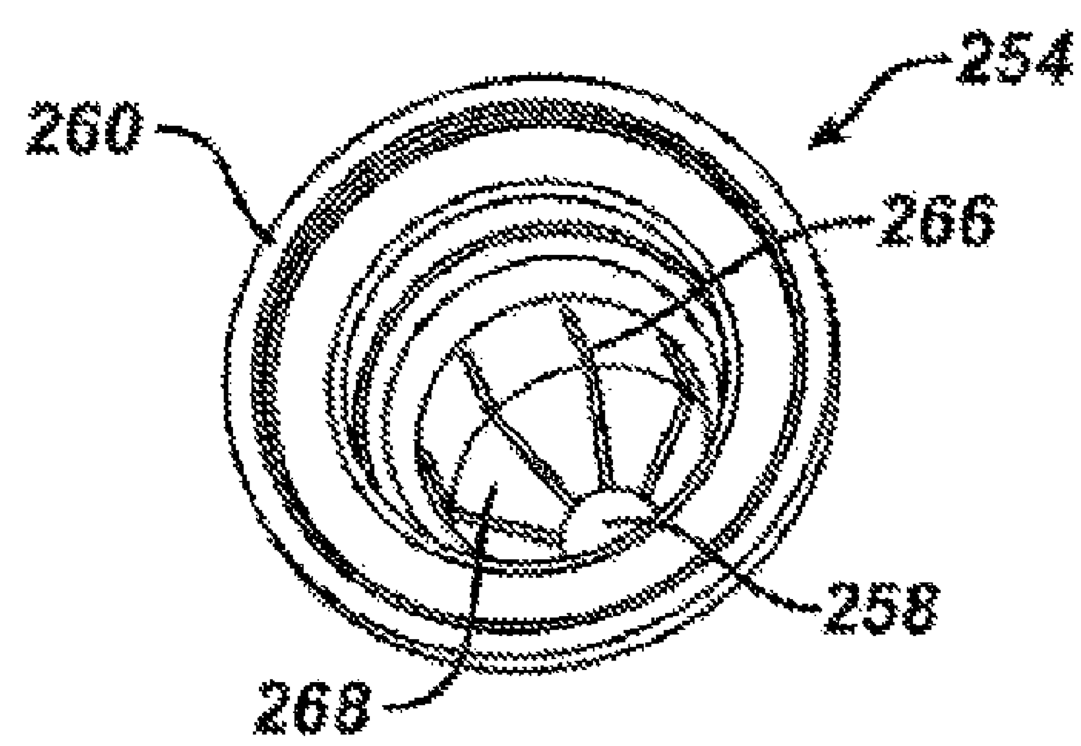


FIG. 21

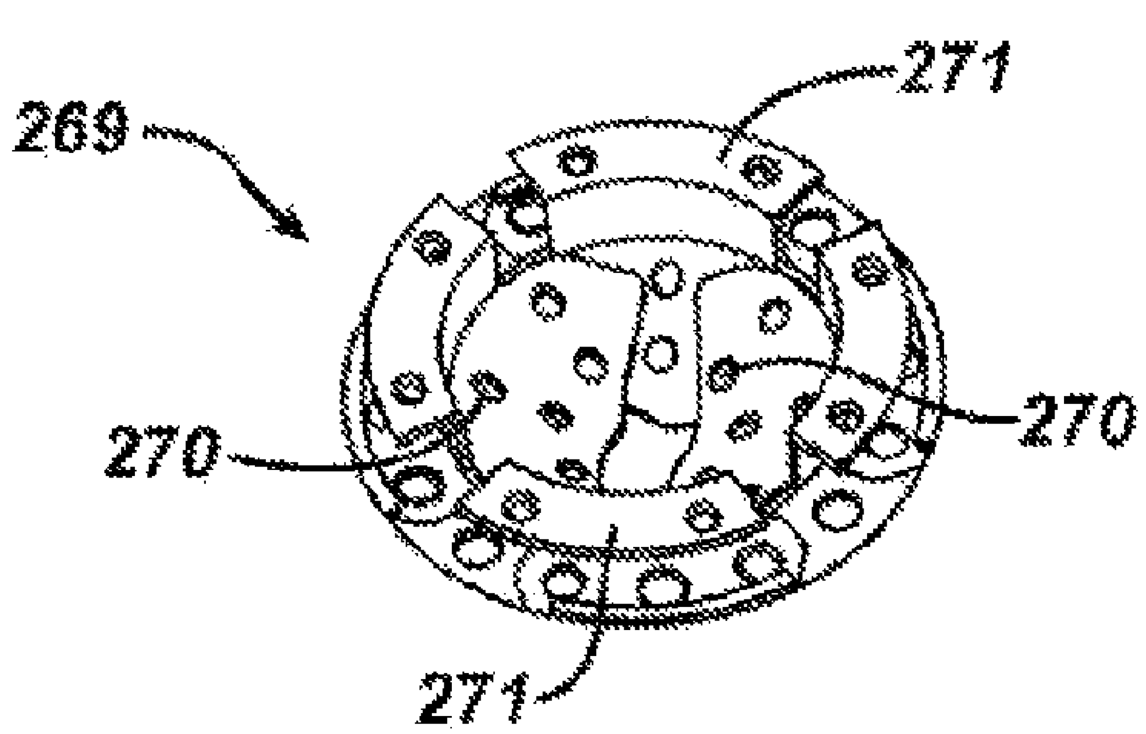


FIG. 22A

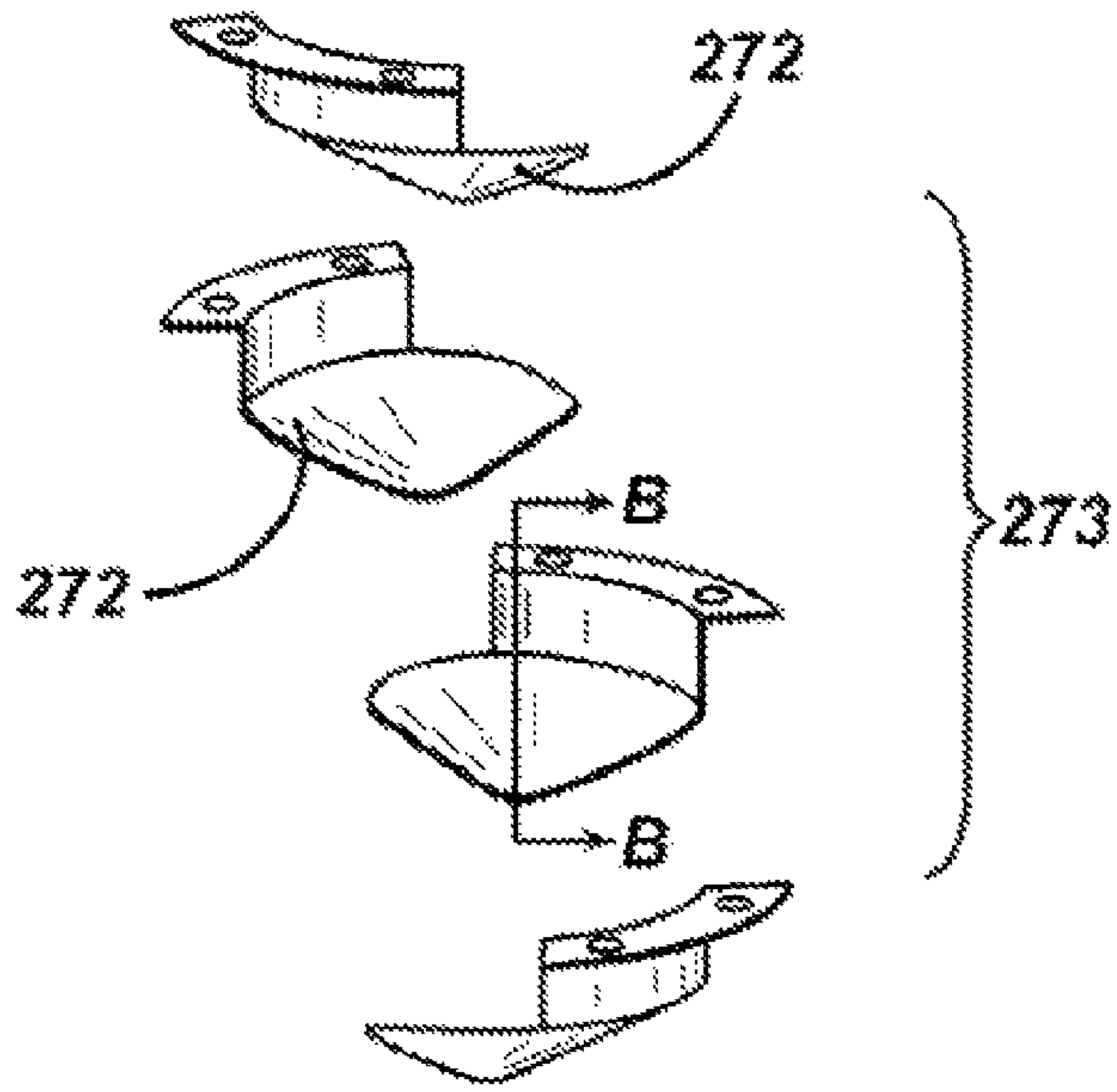


FIG. 22B

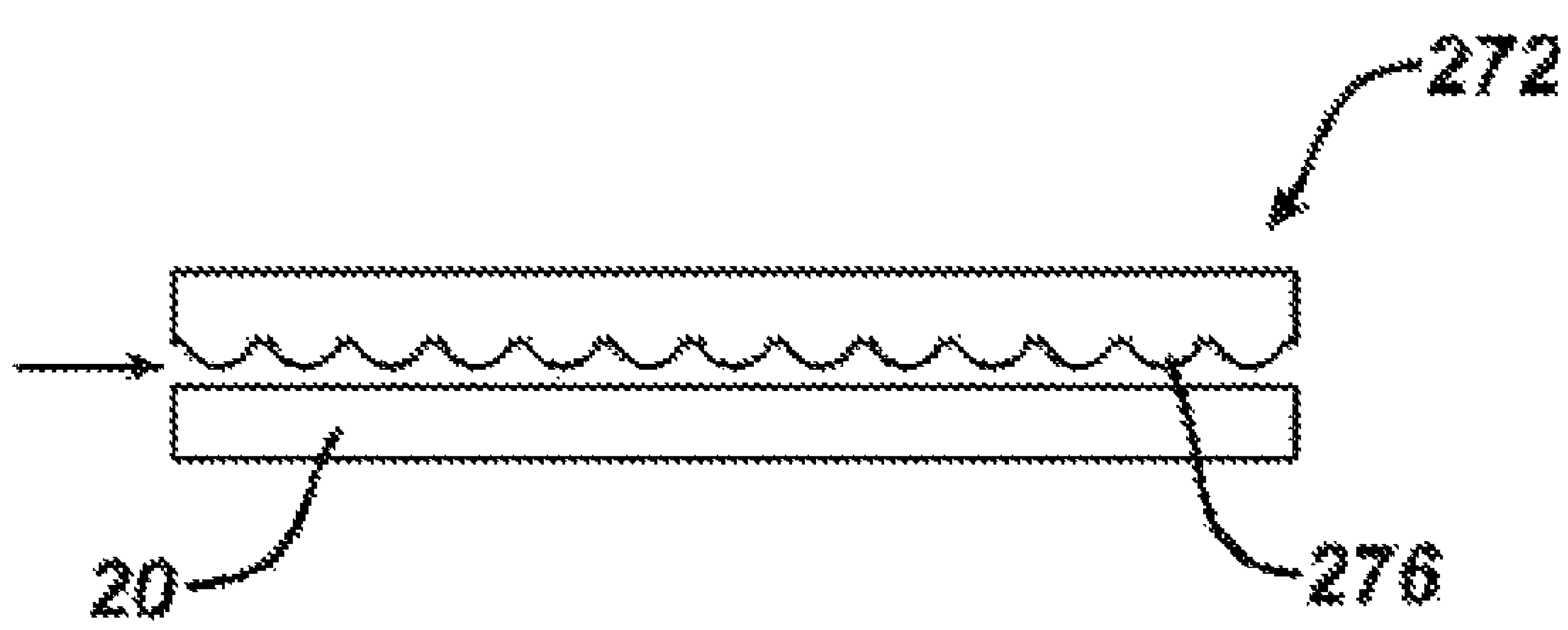


FIG. 23A

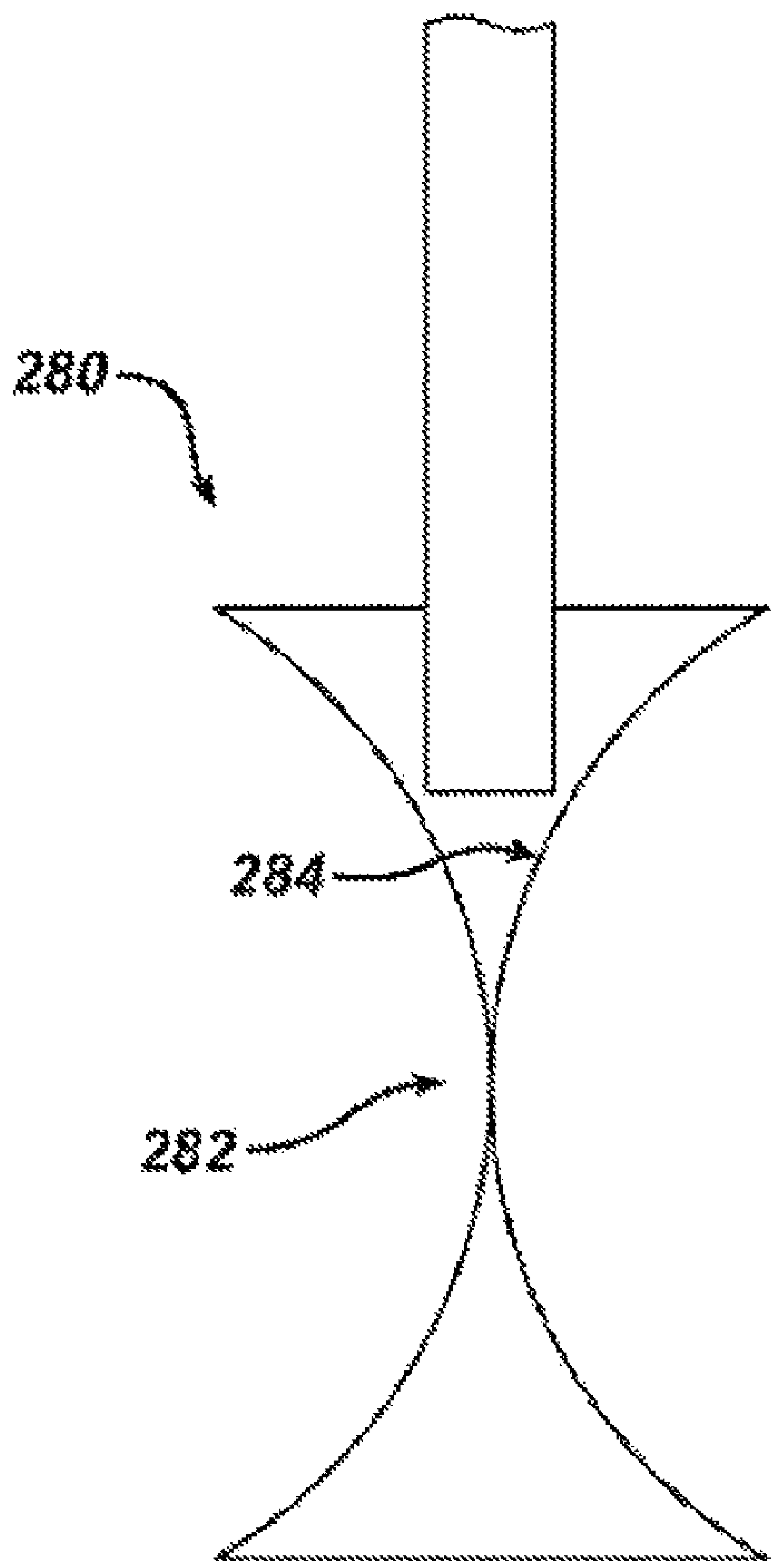


FIG. 23B

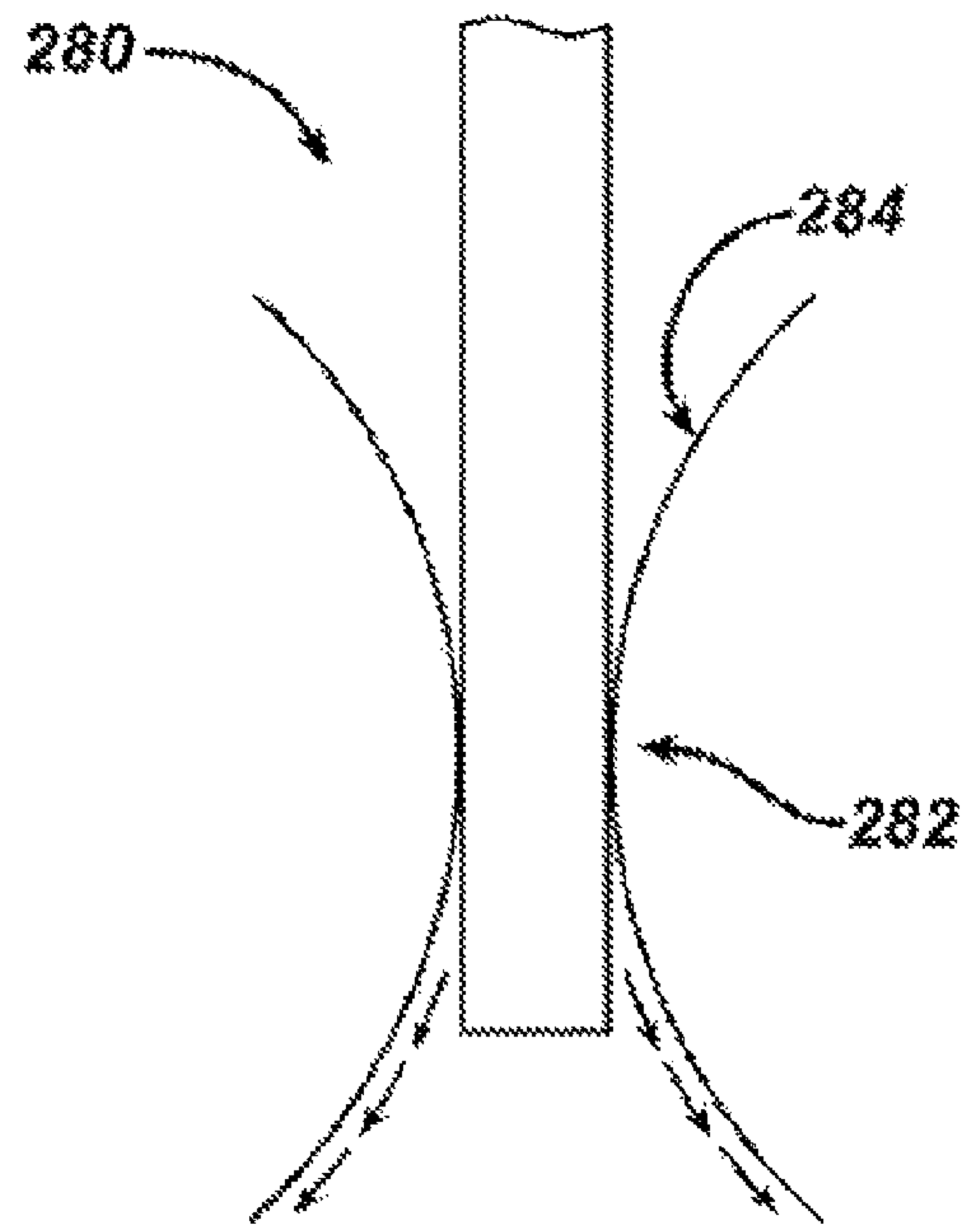


FIG. 24A

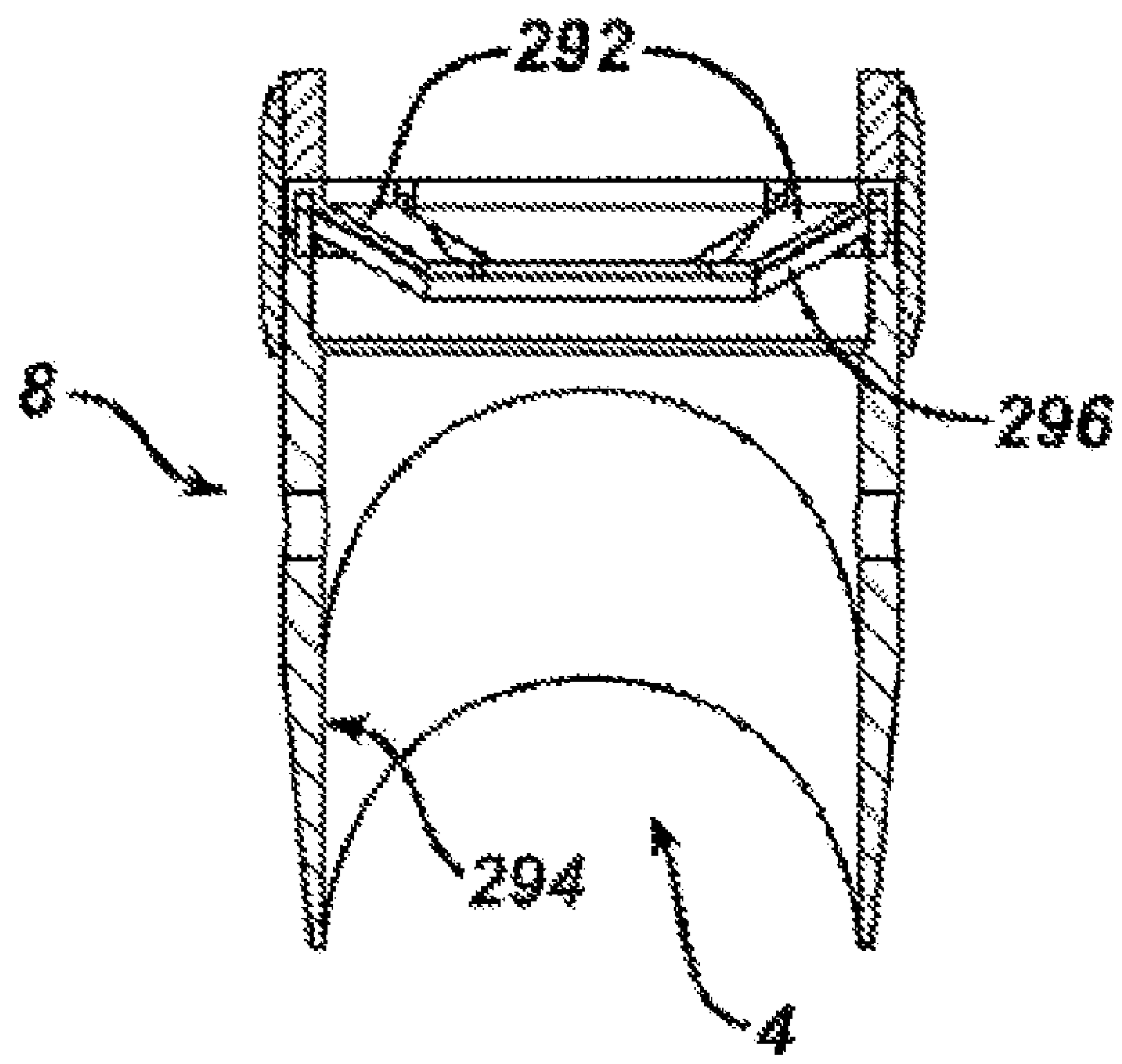


FIG. 24B

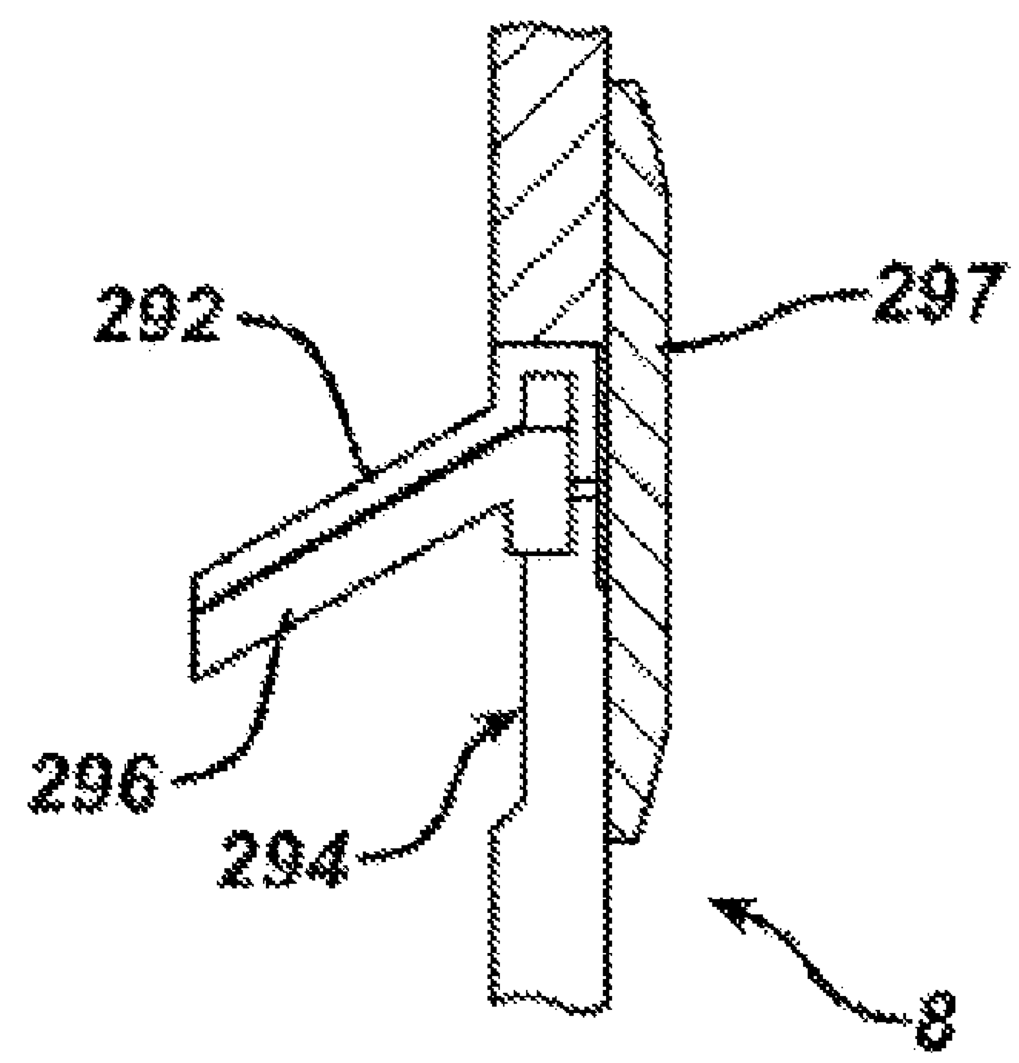


FIG. 25

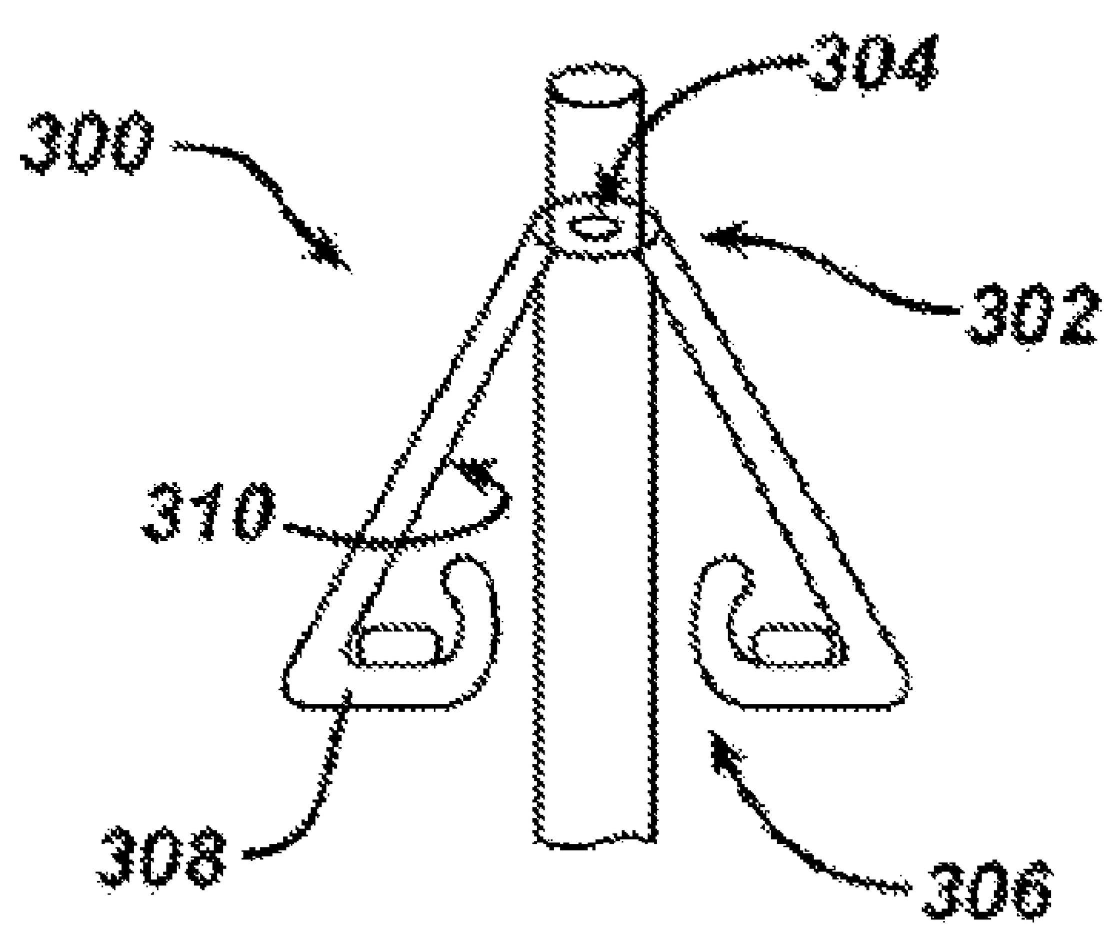


FIG. 26

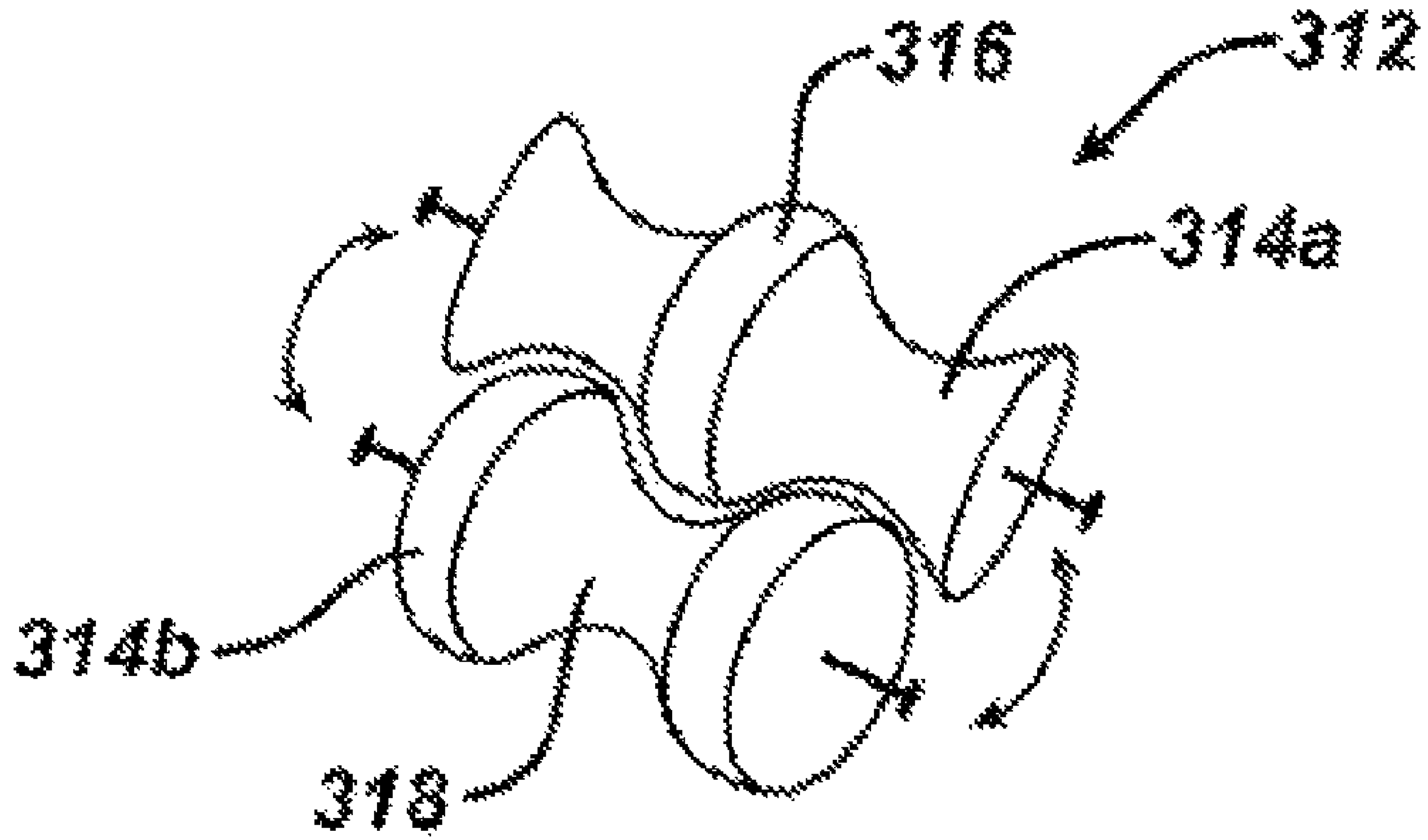


FIG. 27A

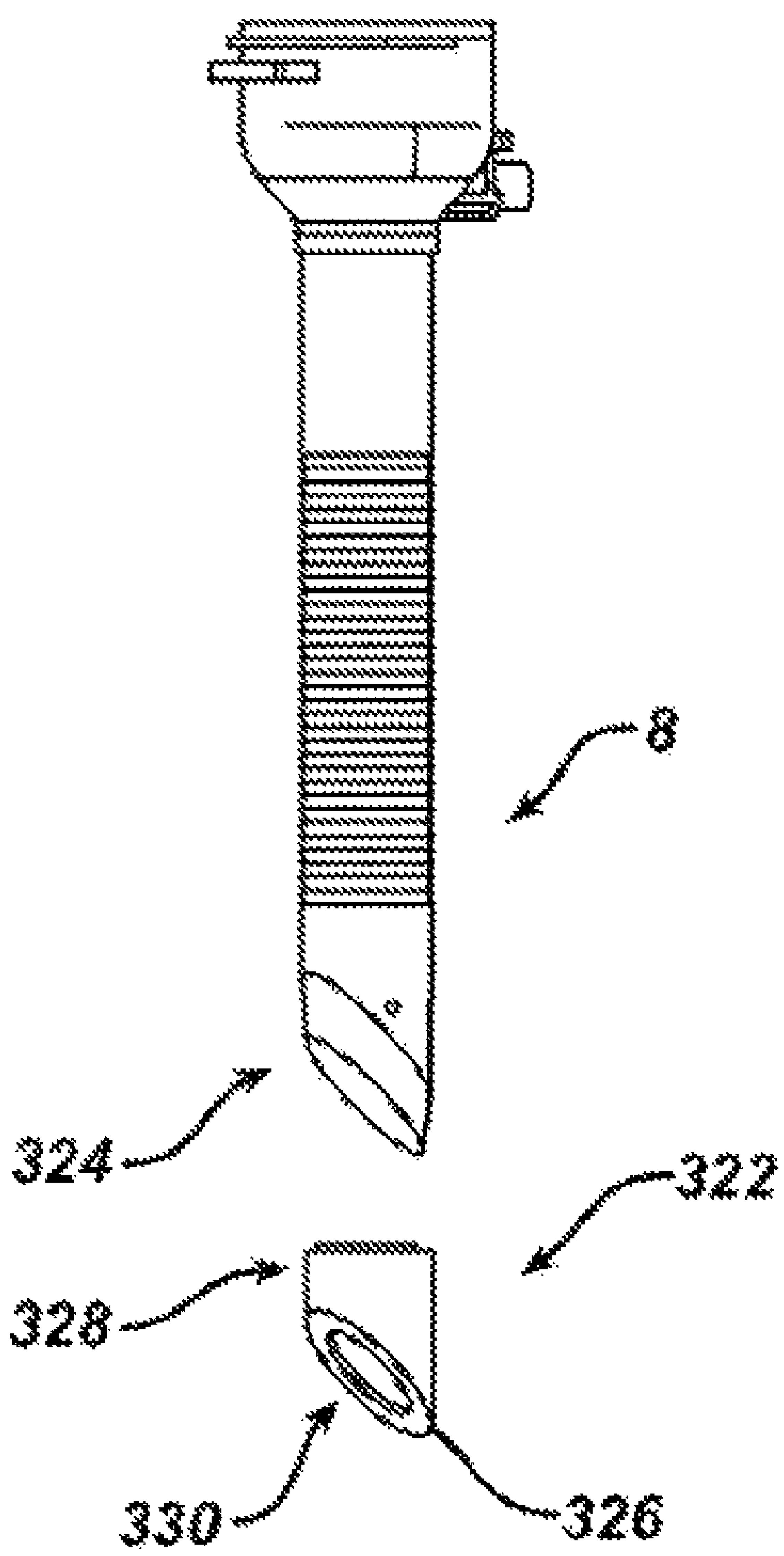


FIG. 27B

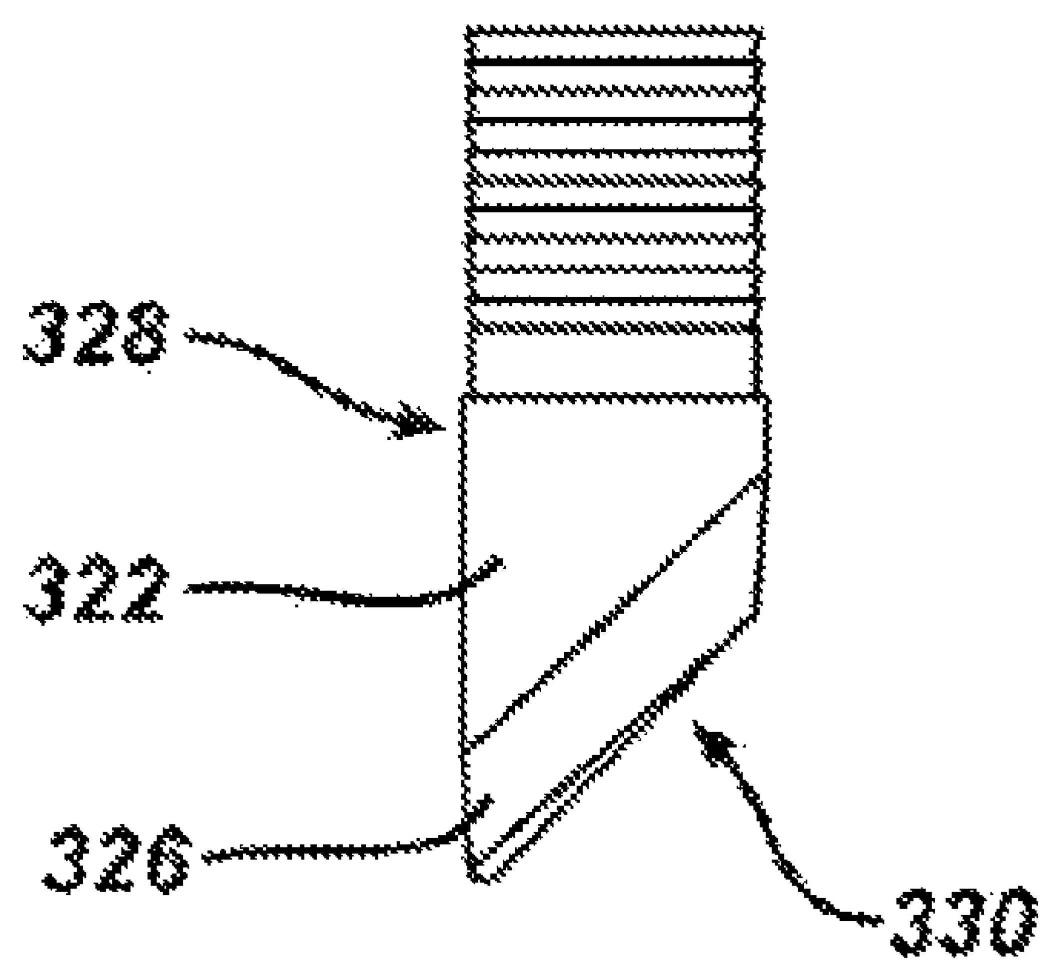


FIG. 27C

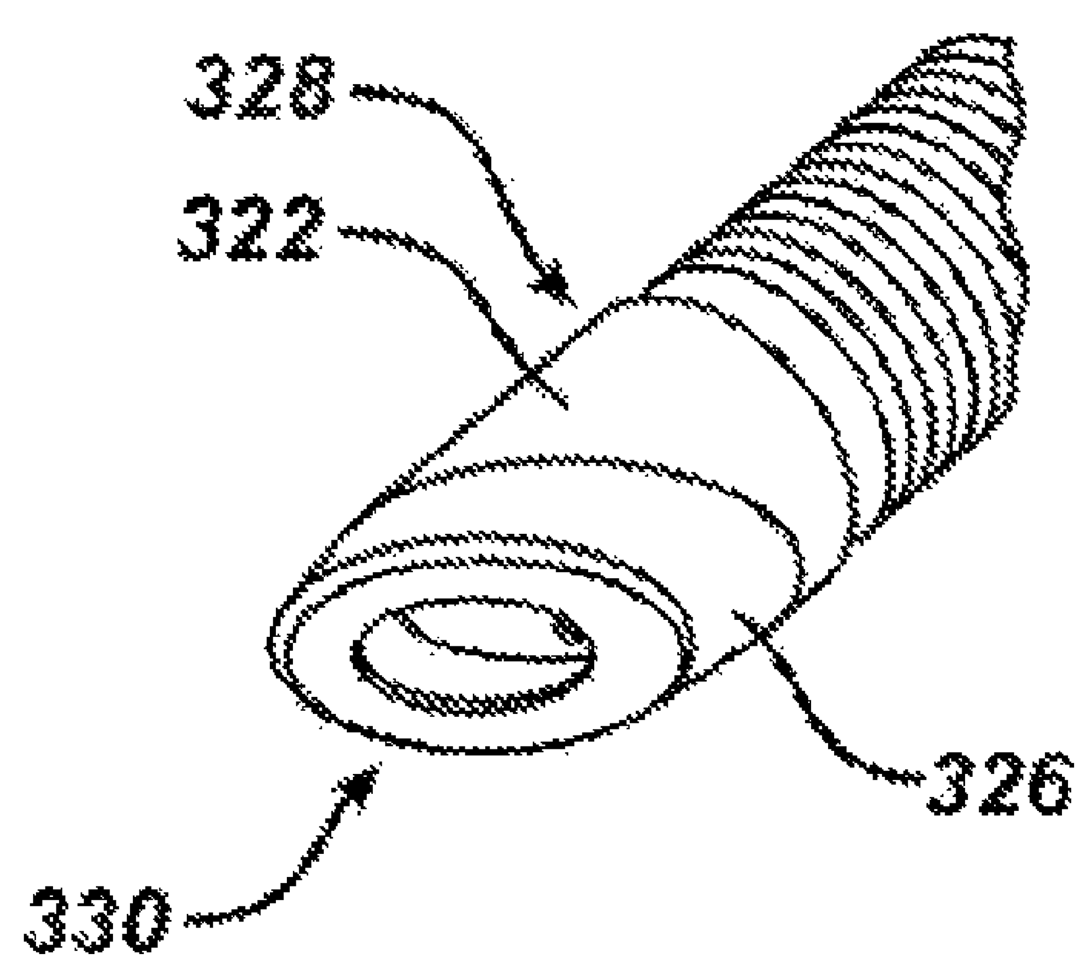
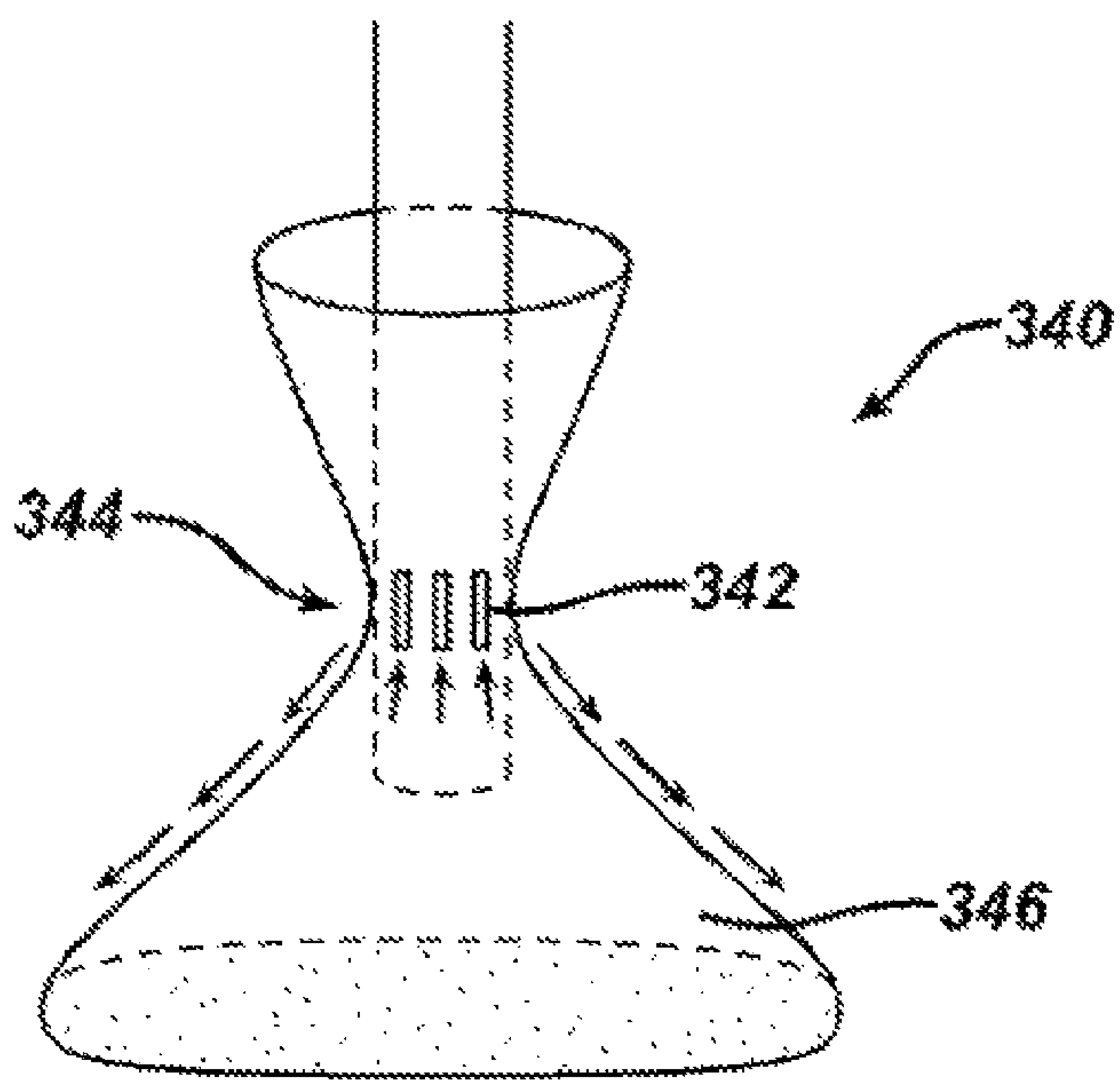


FIG. 28



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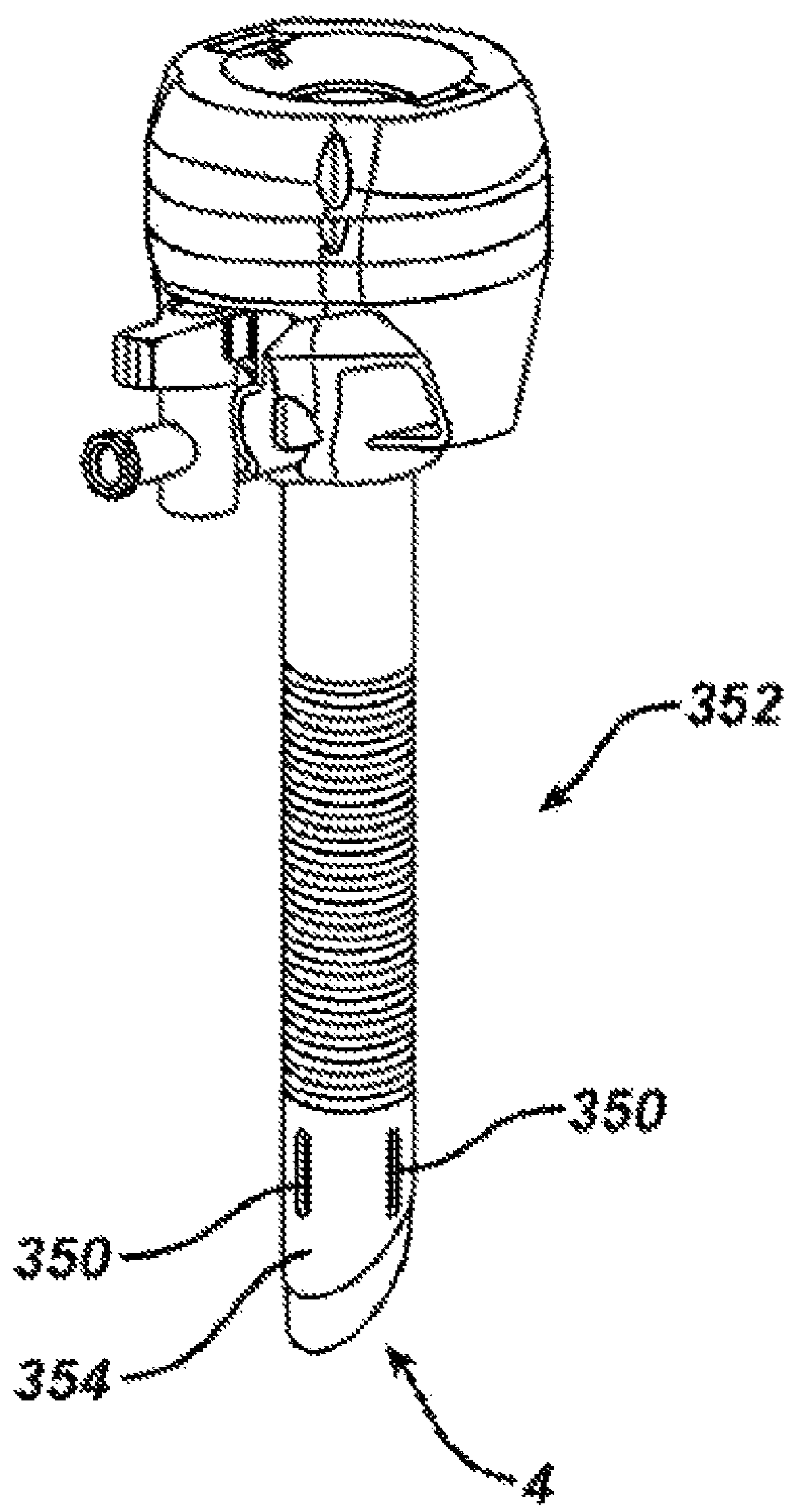


FIG. 30B

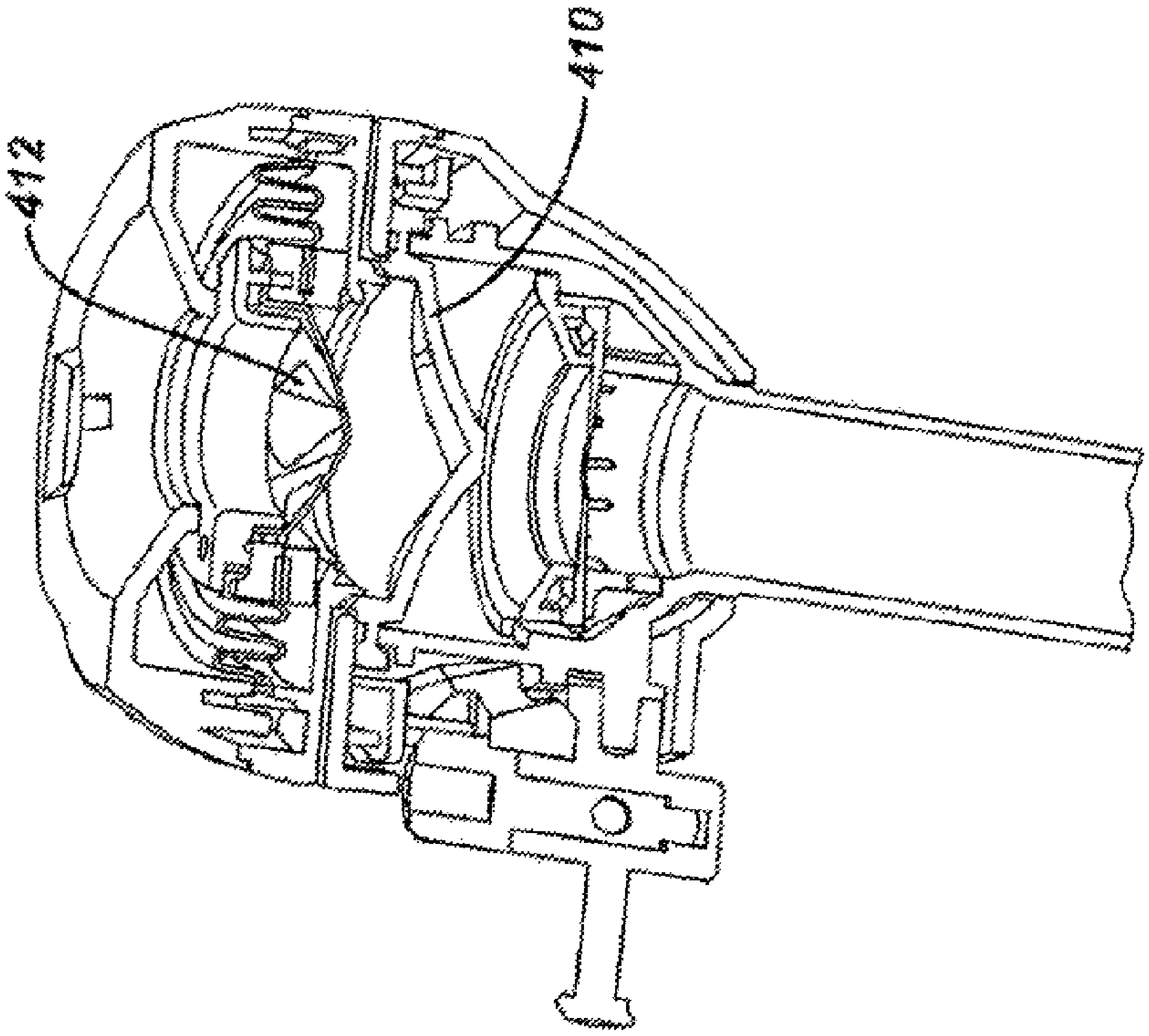


FIG. 30A

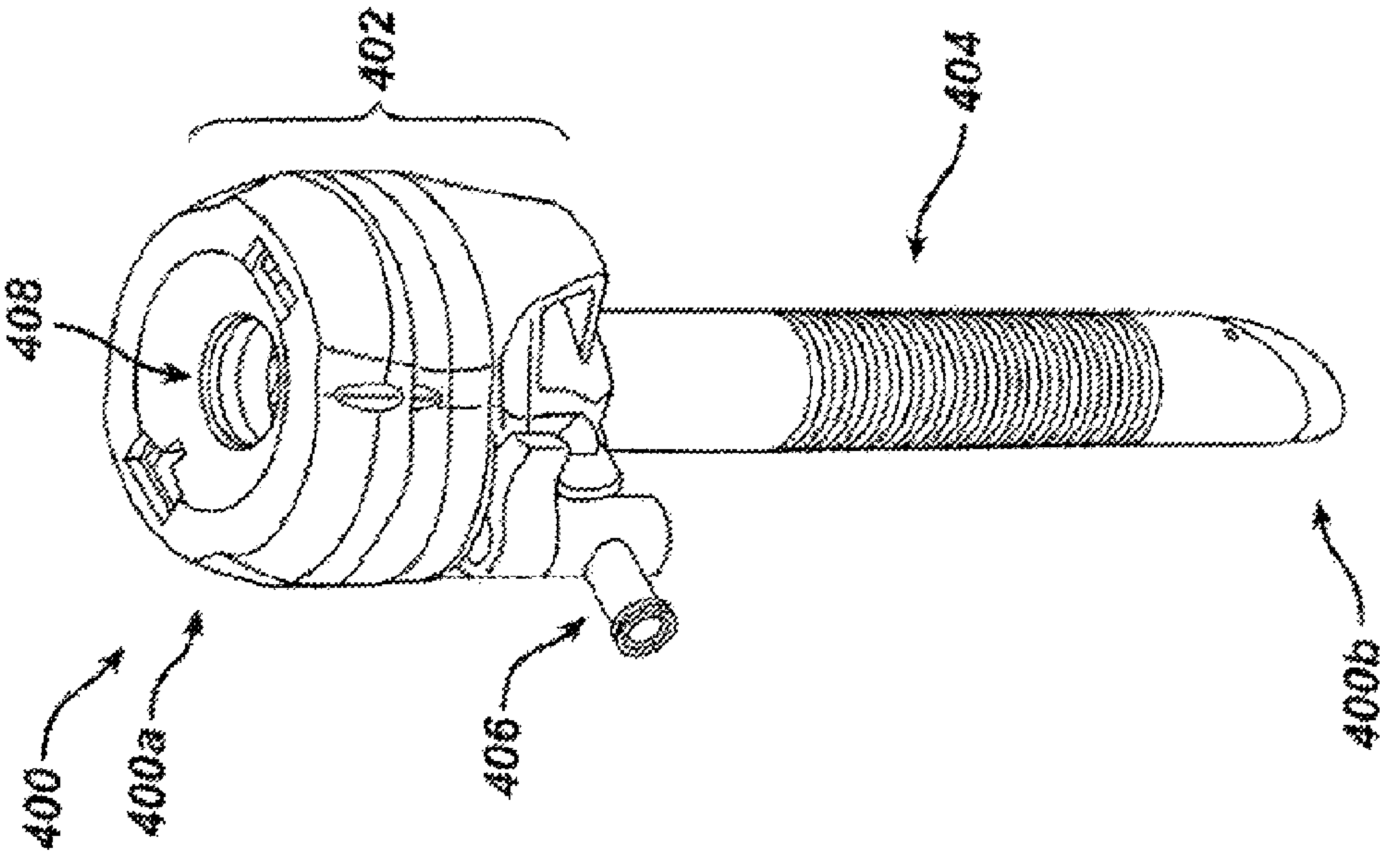


FIG. 30C

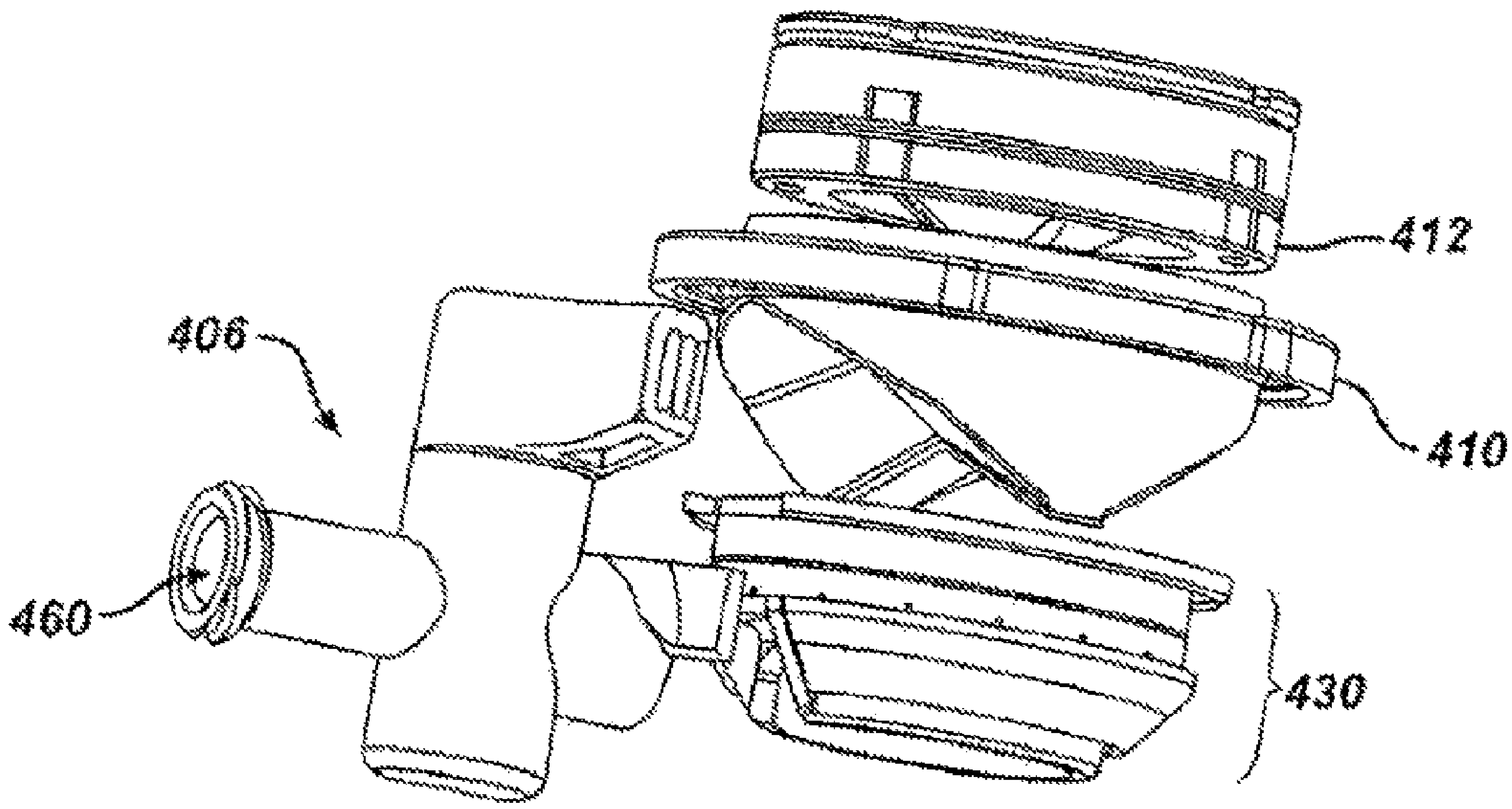


FIG. 30D

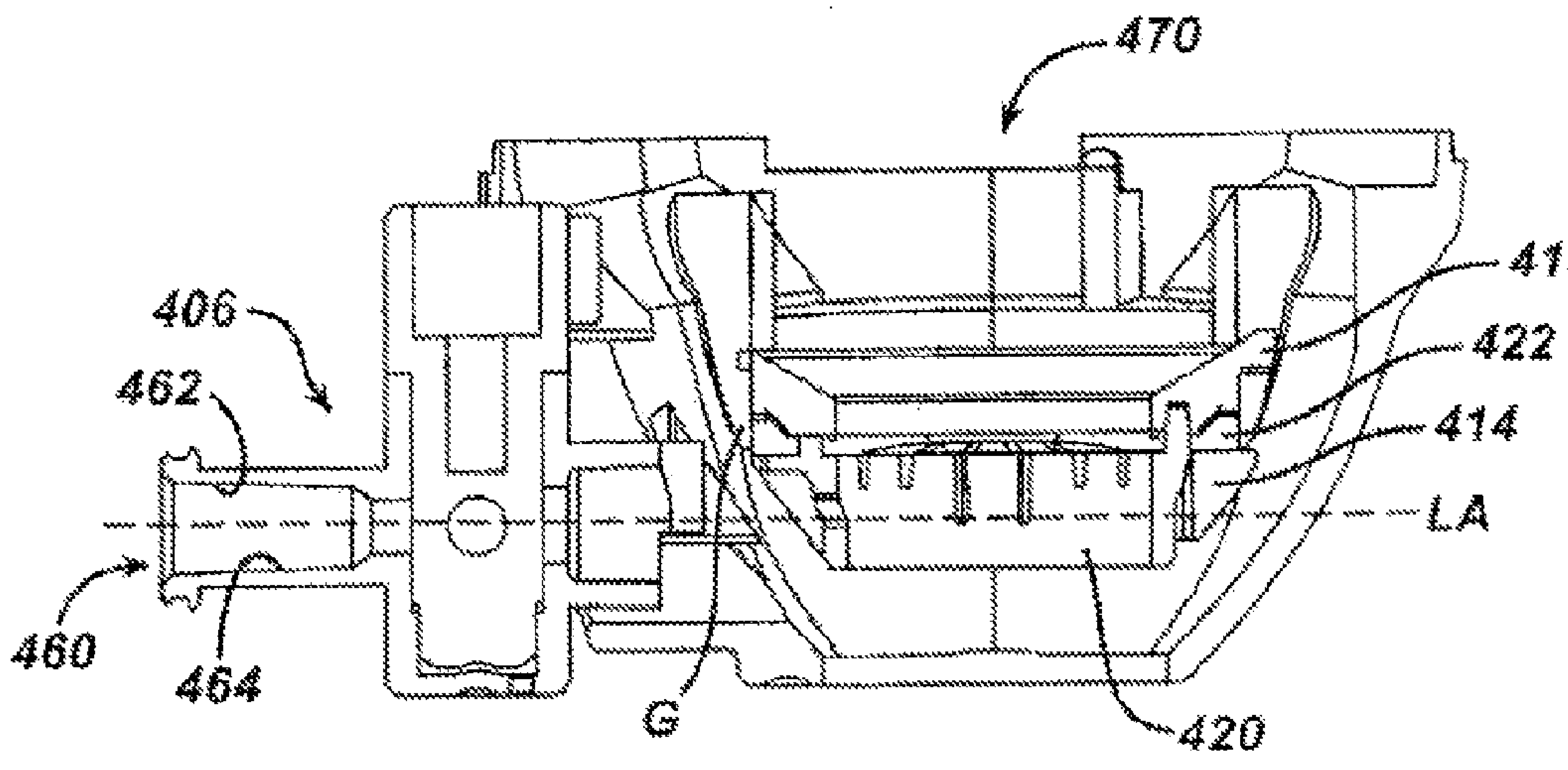


FIG. 30E

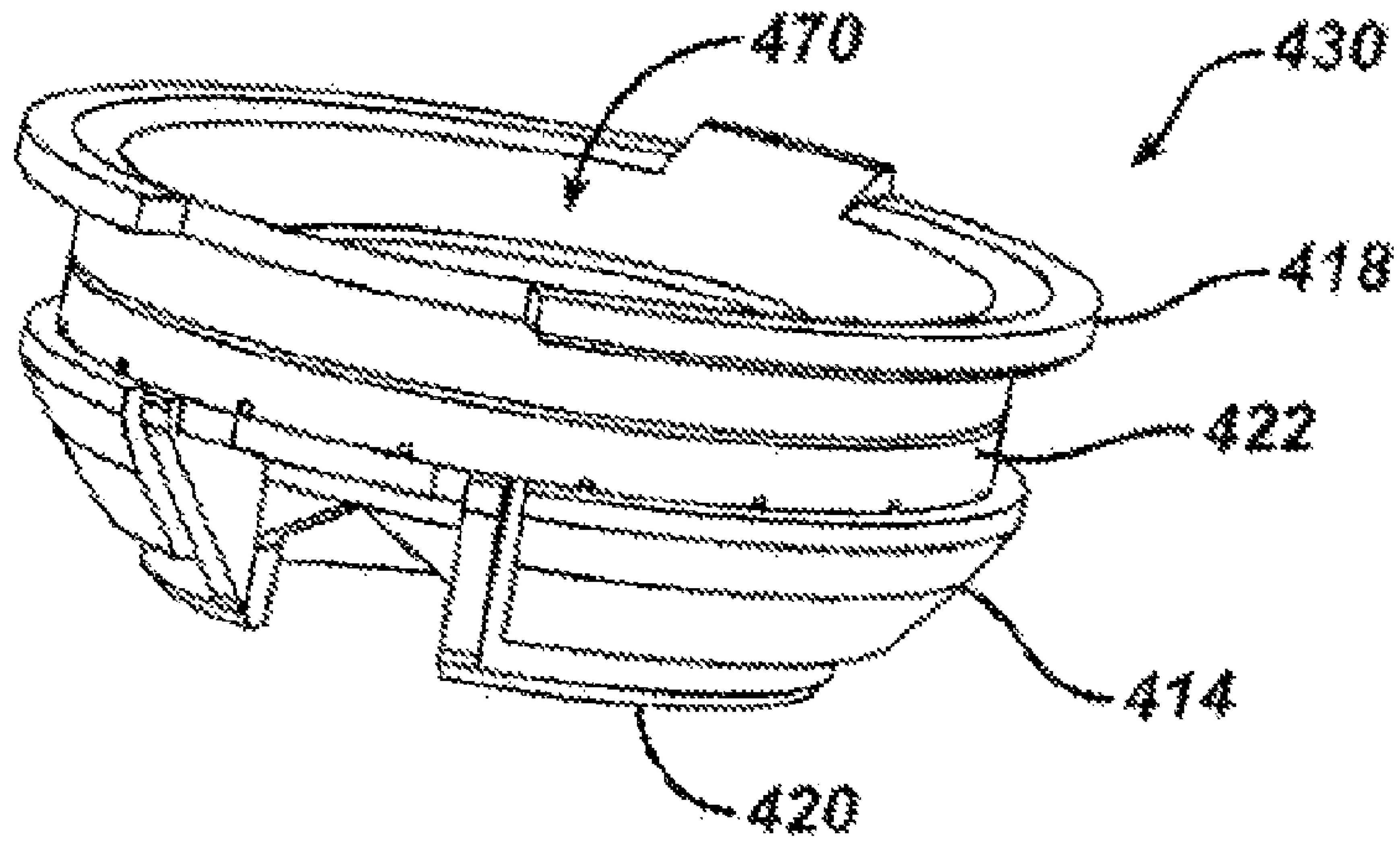


FIG. 30F

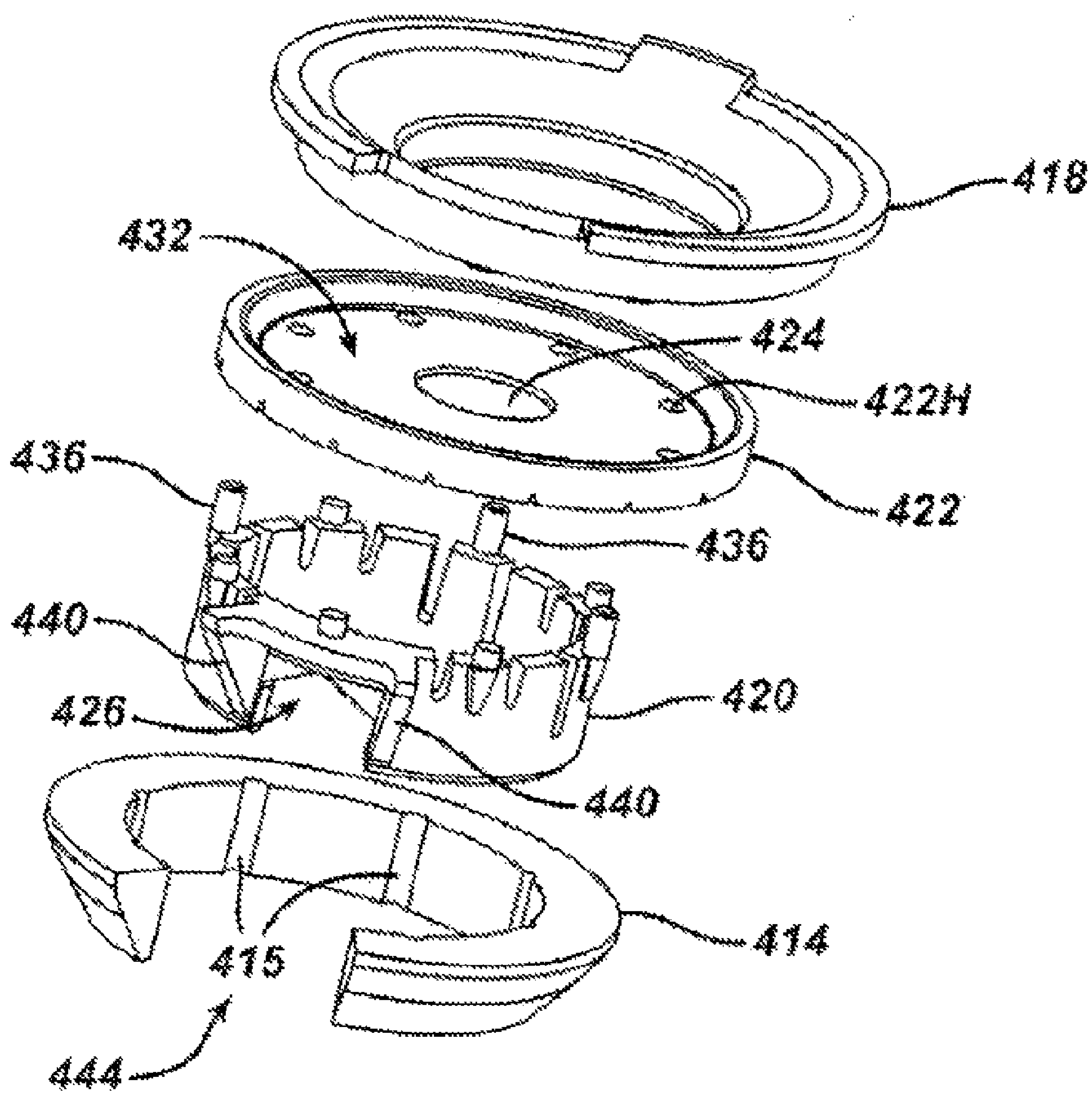


FIG. 30G

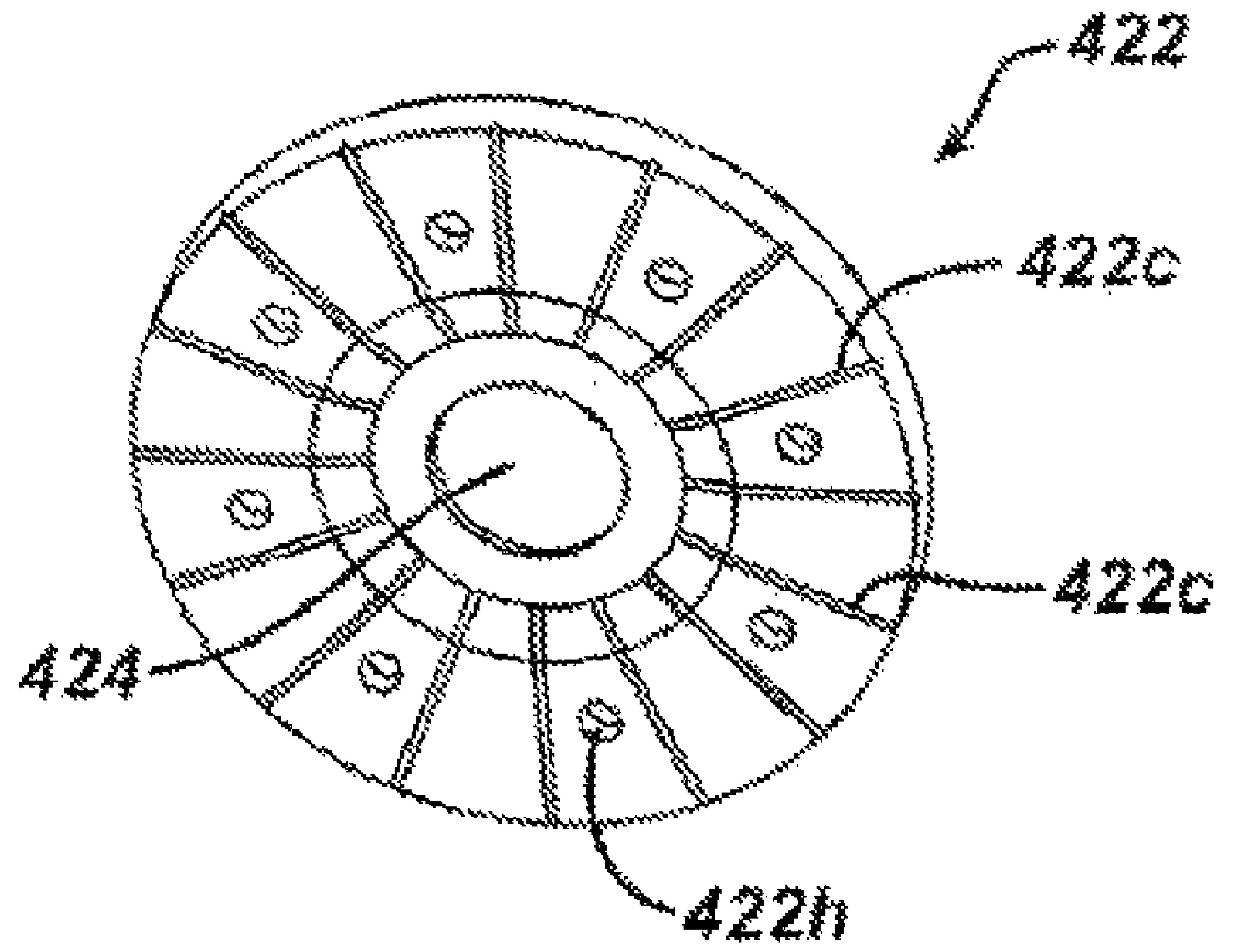


FIG. 30H

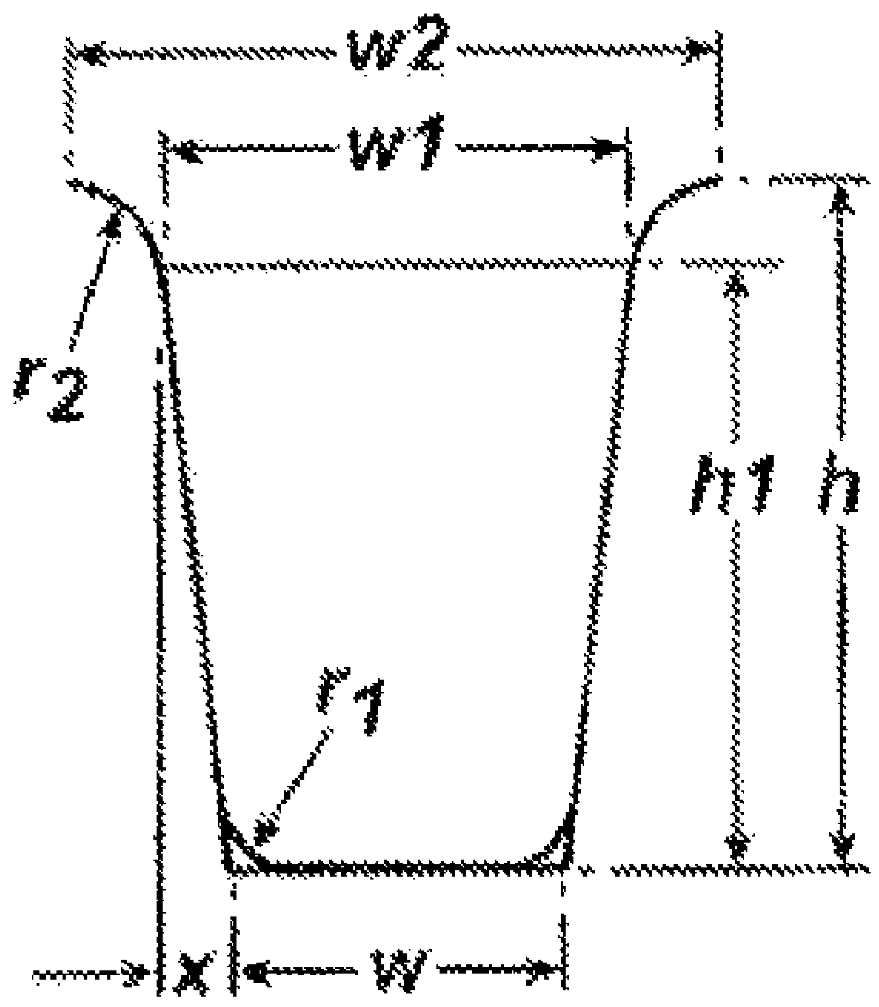


FIG. 30I

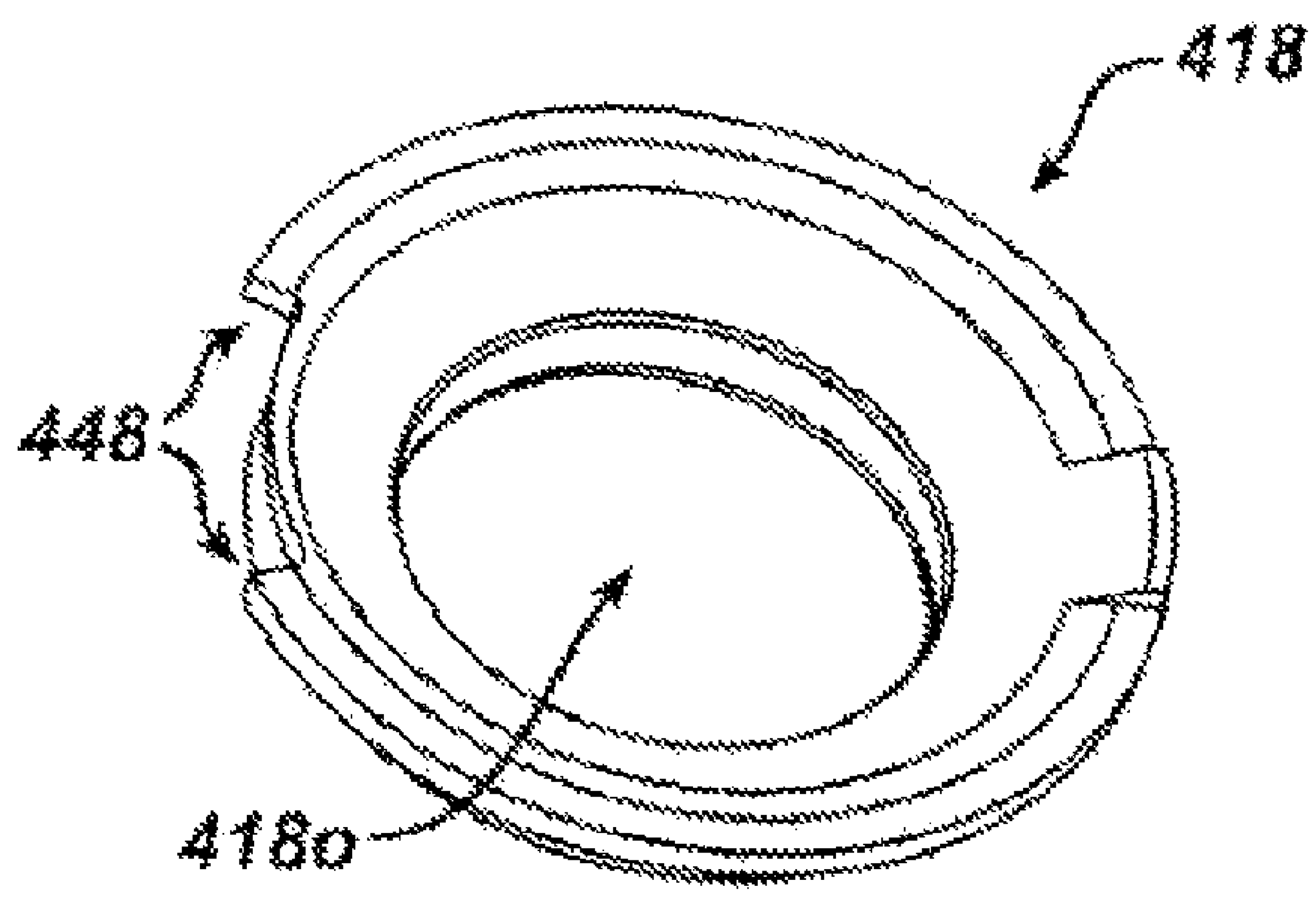


FIG. 30J

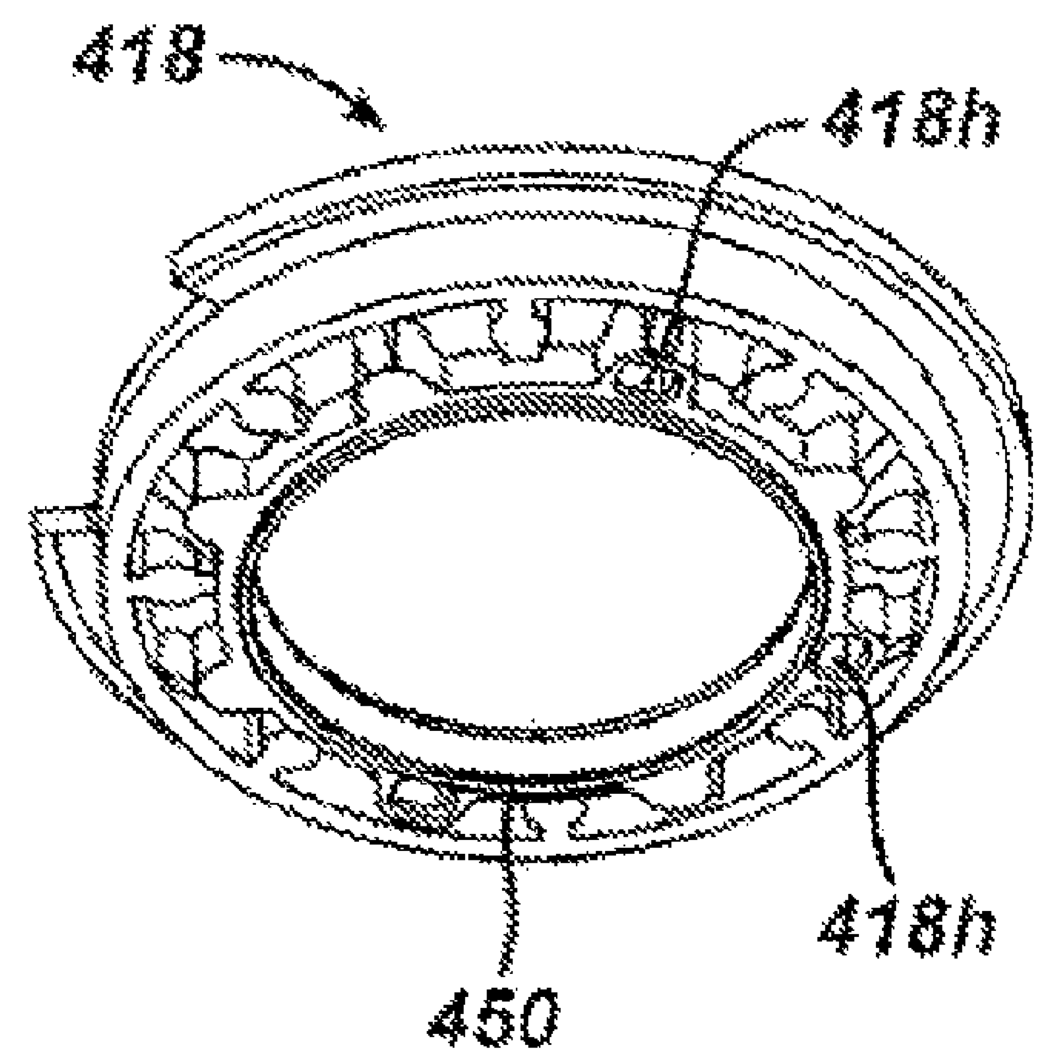


FIG. 31

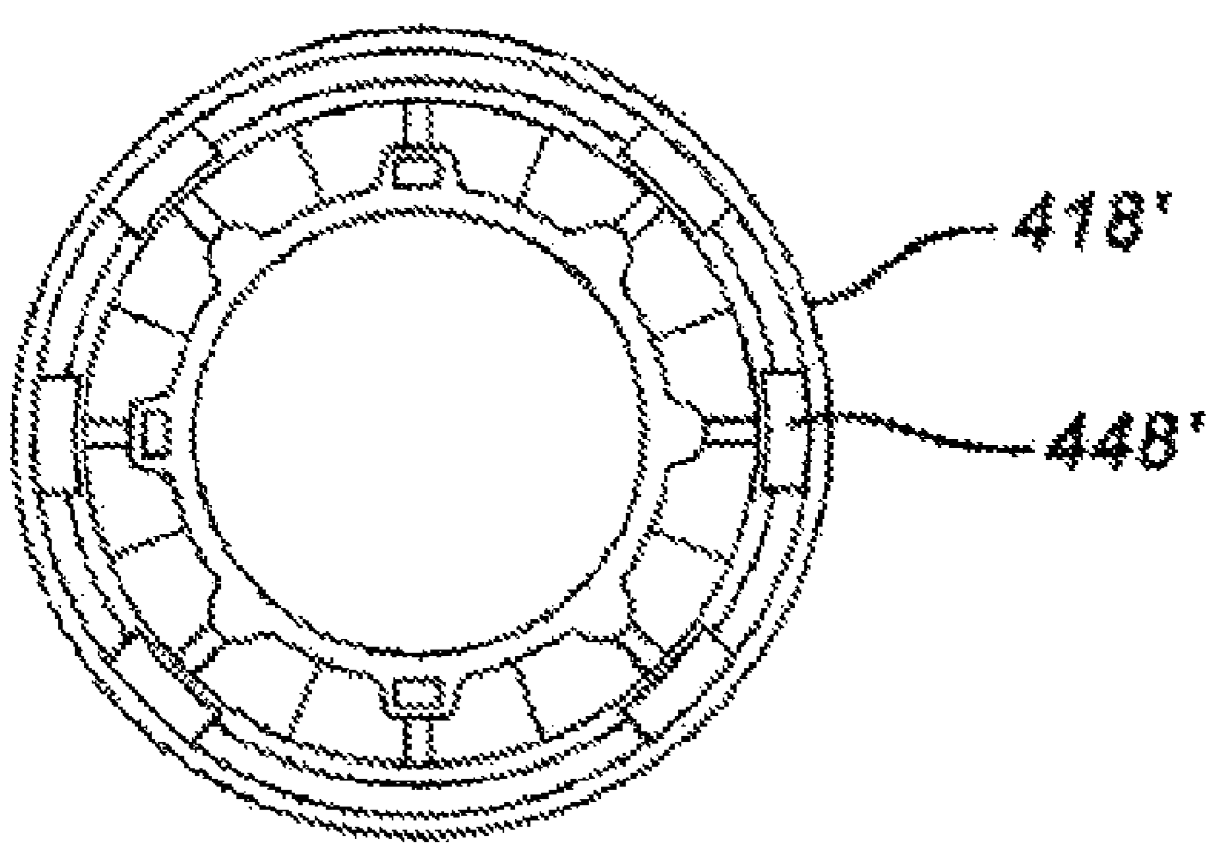


FIG. 32A

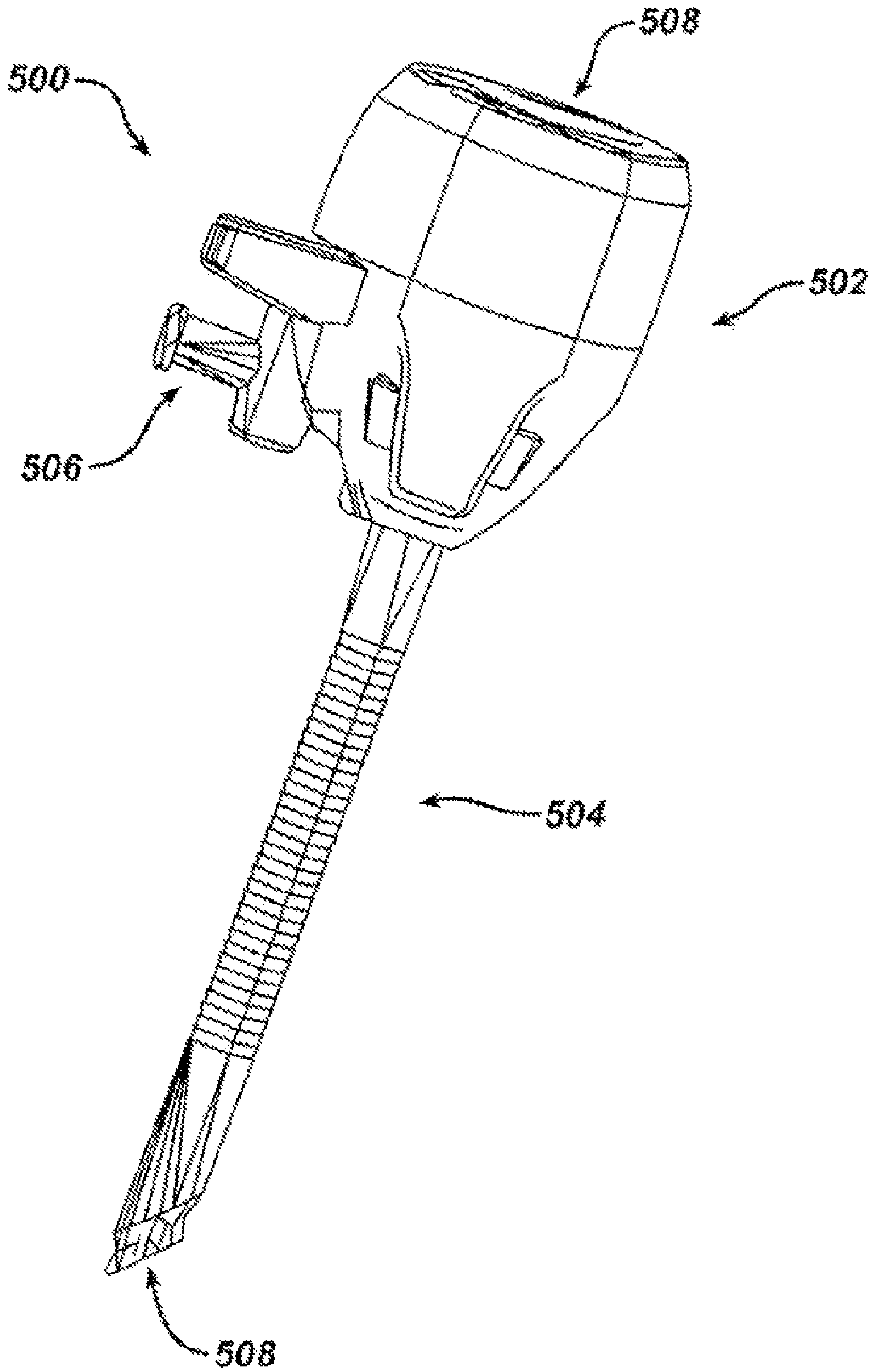


FIG. 32B

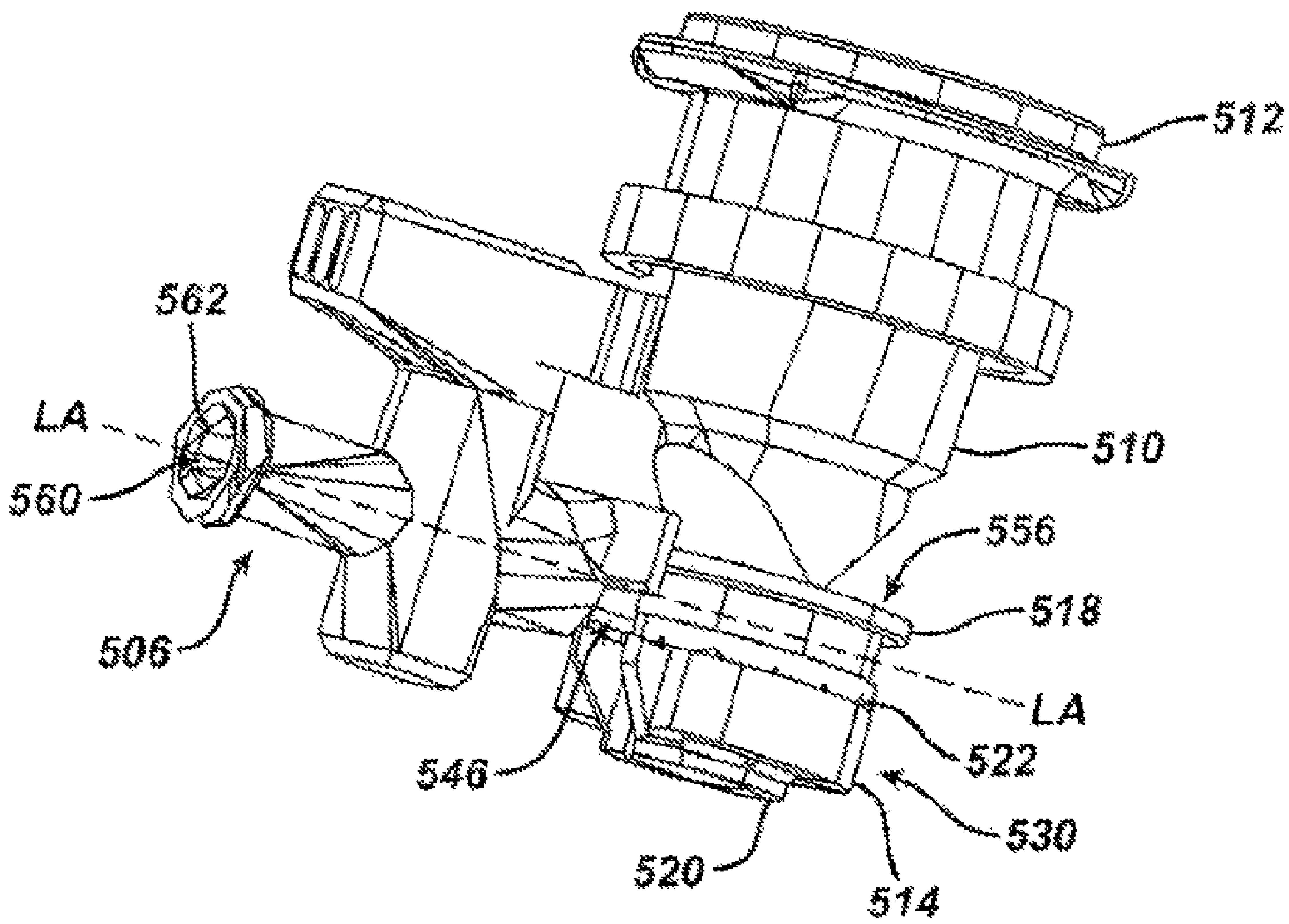


FIG. 32C

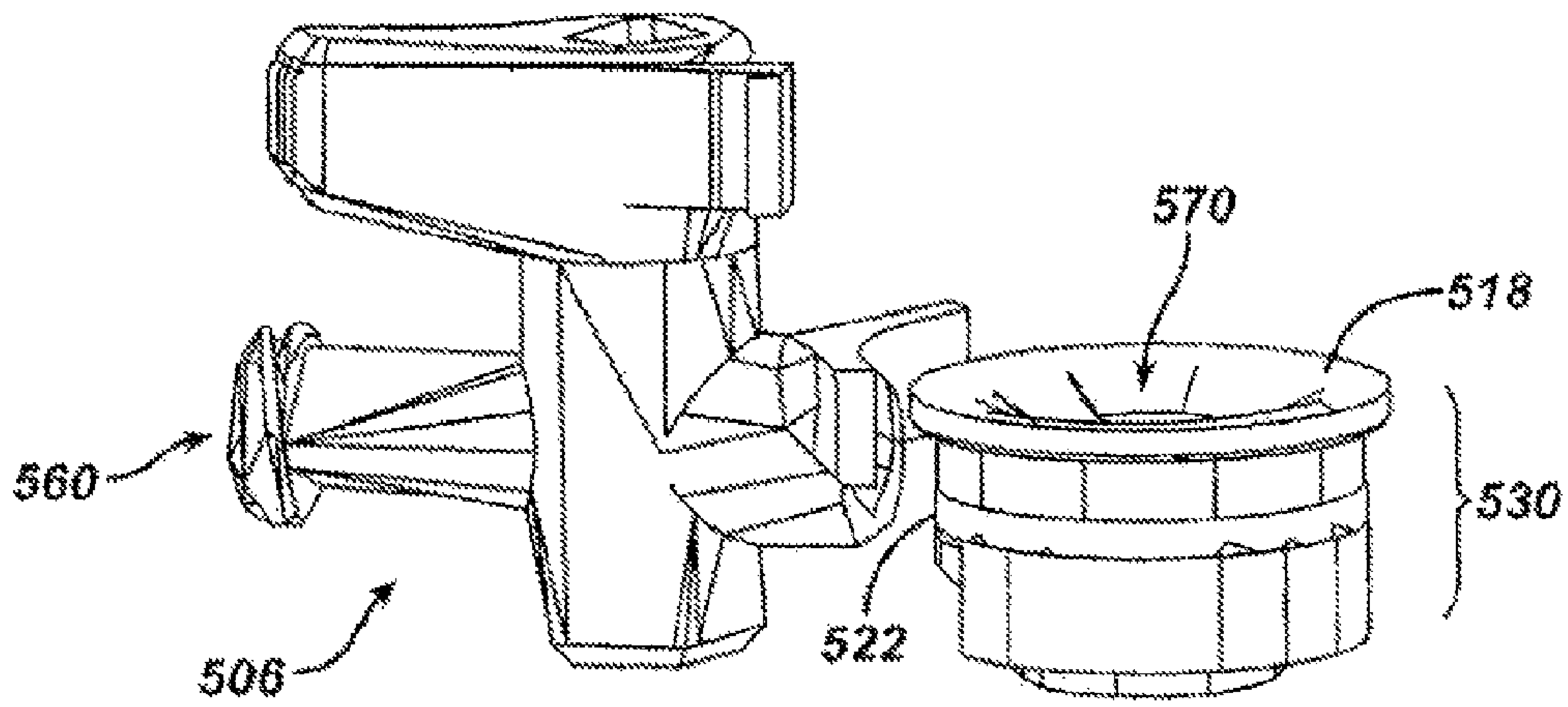
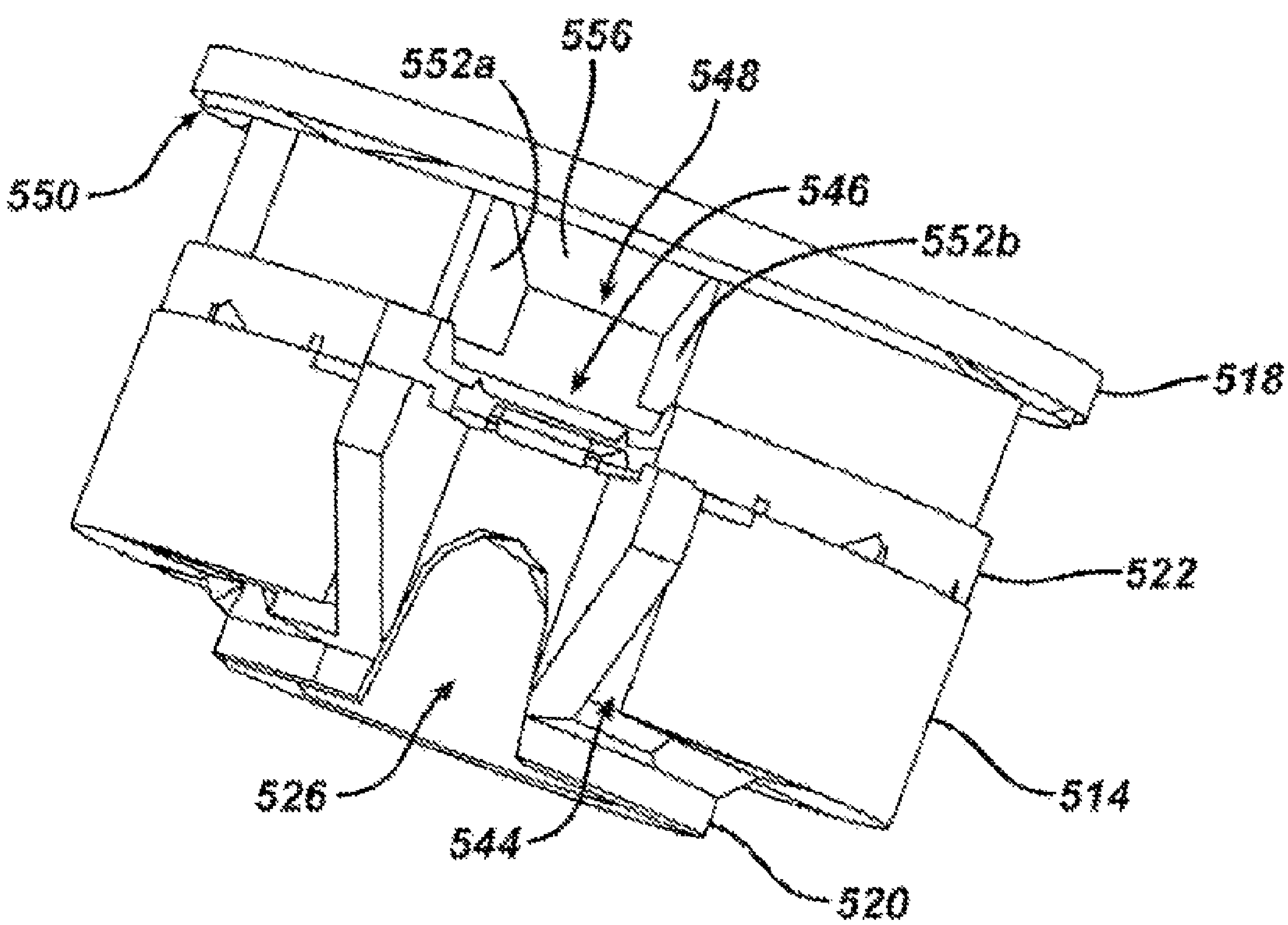


FIG. 32D



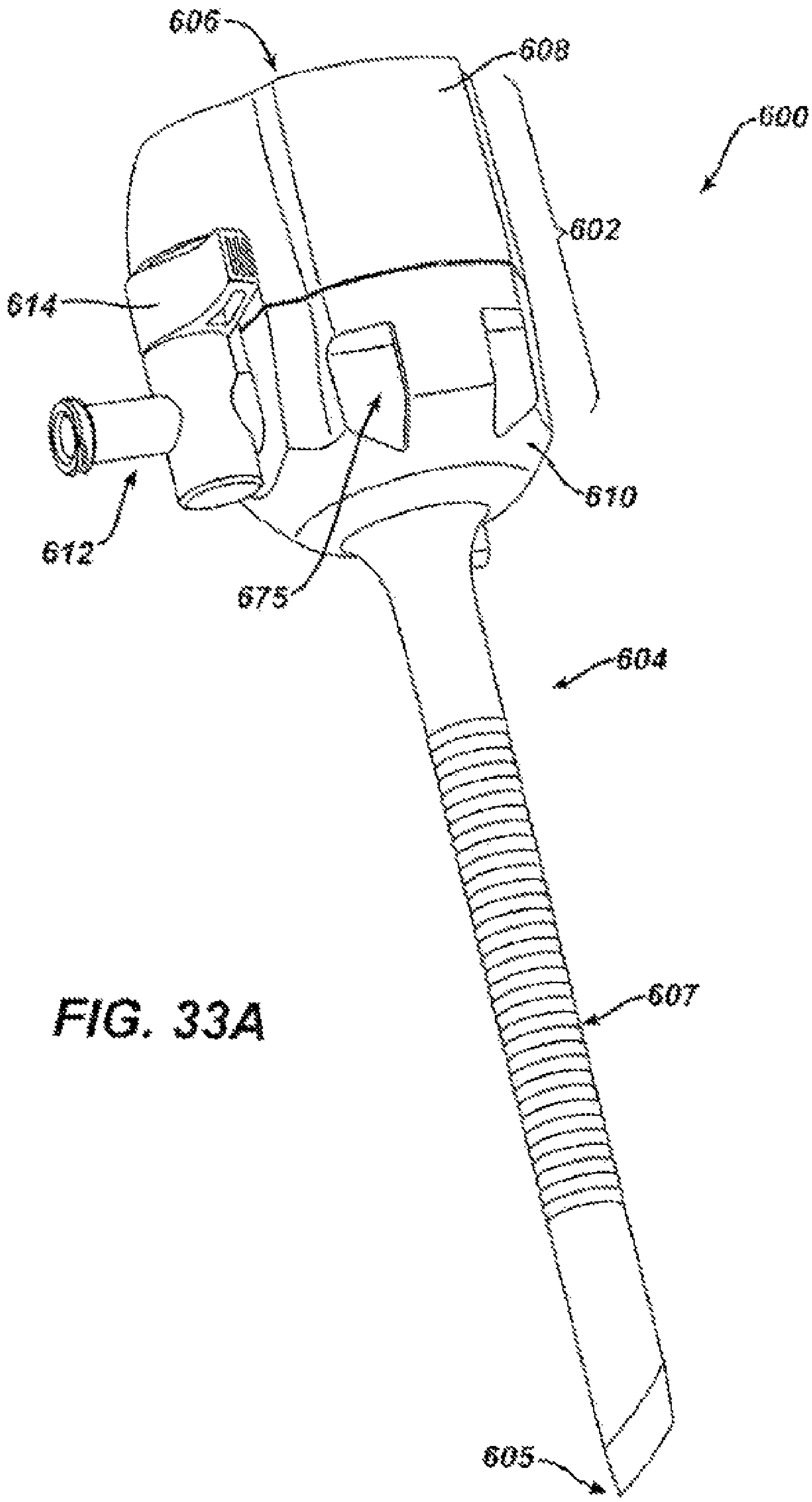


FIG. 33A

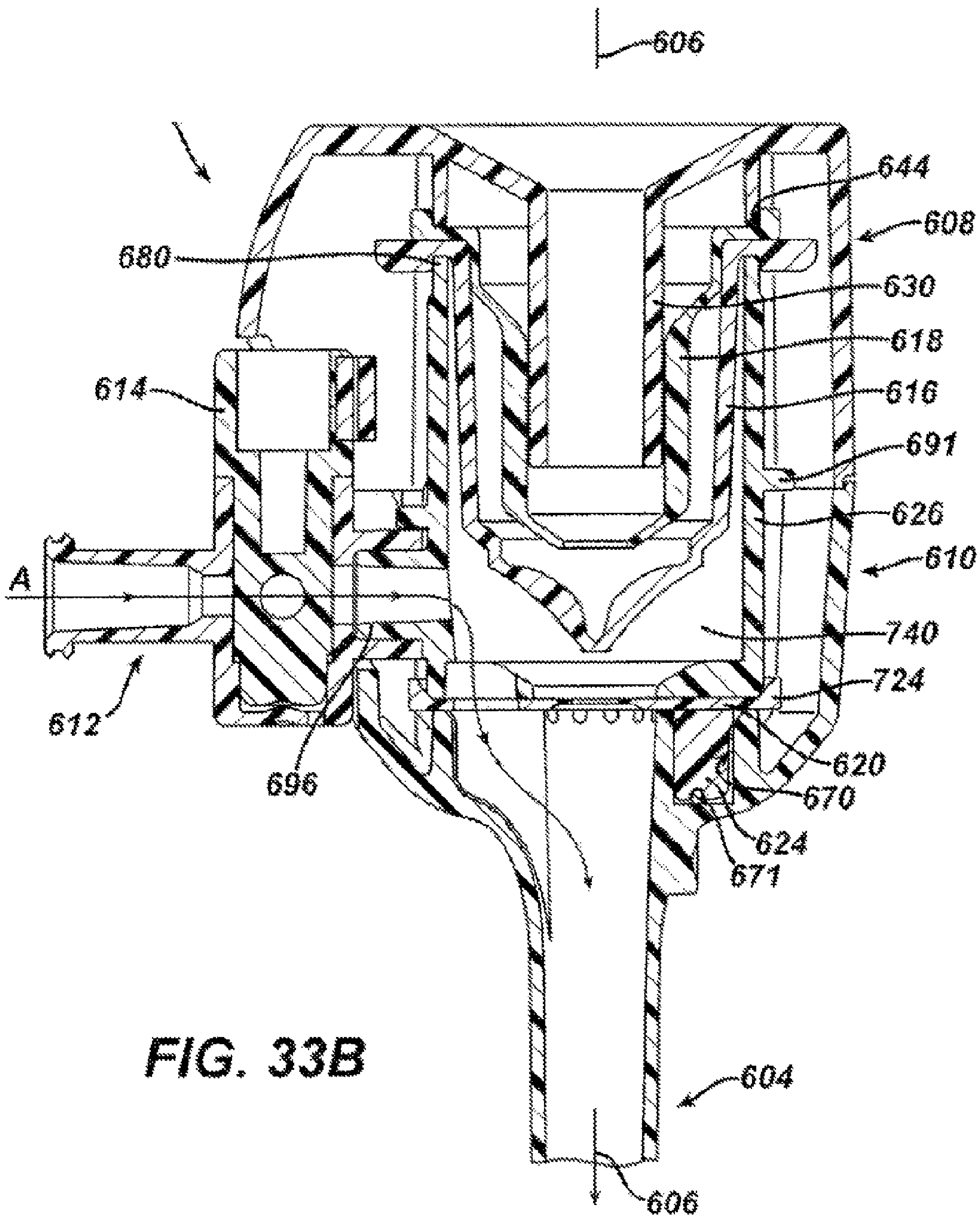

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FIG. 33B

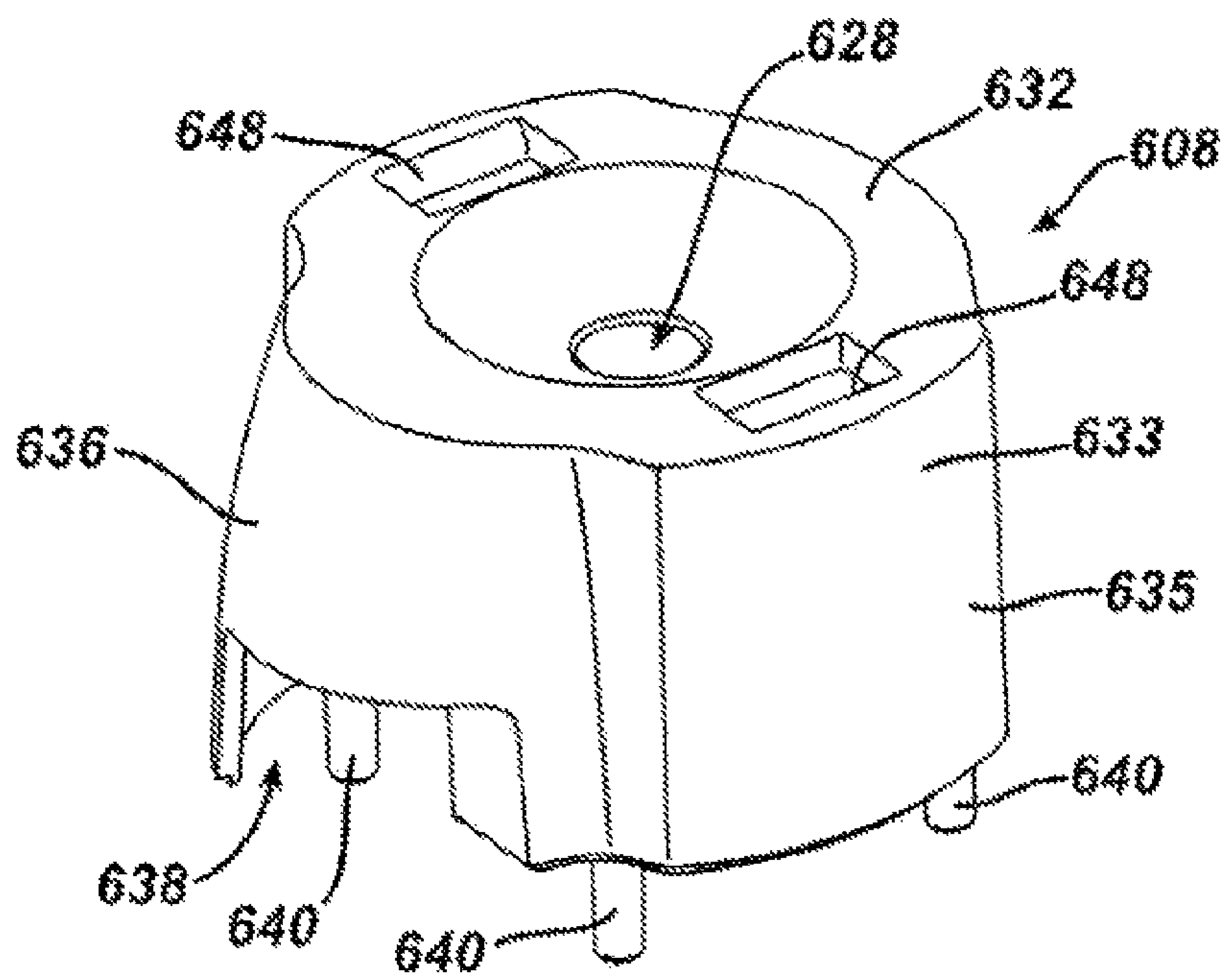

FIG. 34A

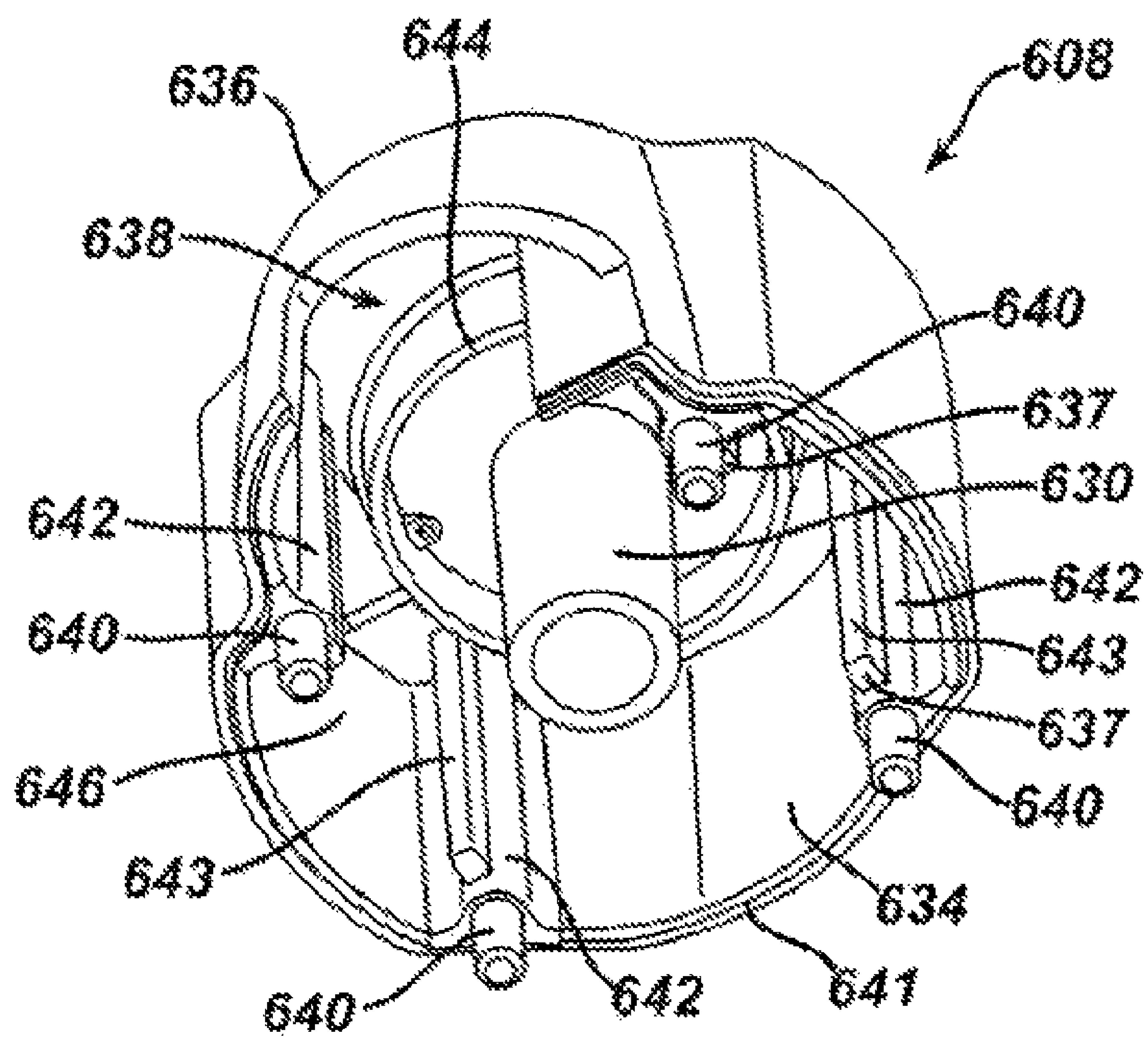

FIG. 34B

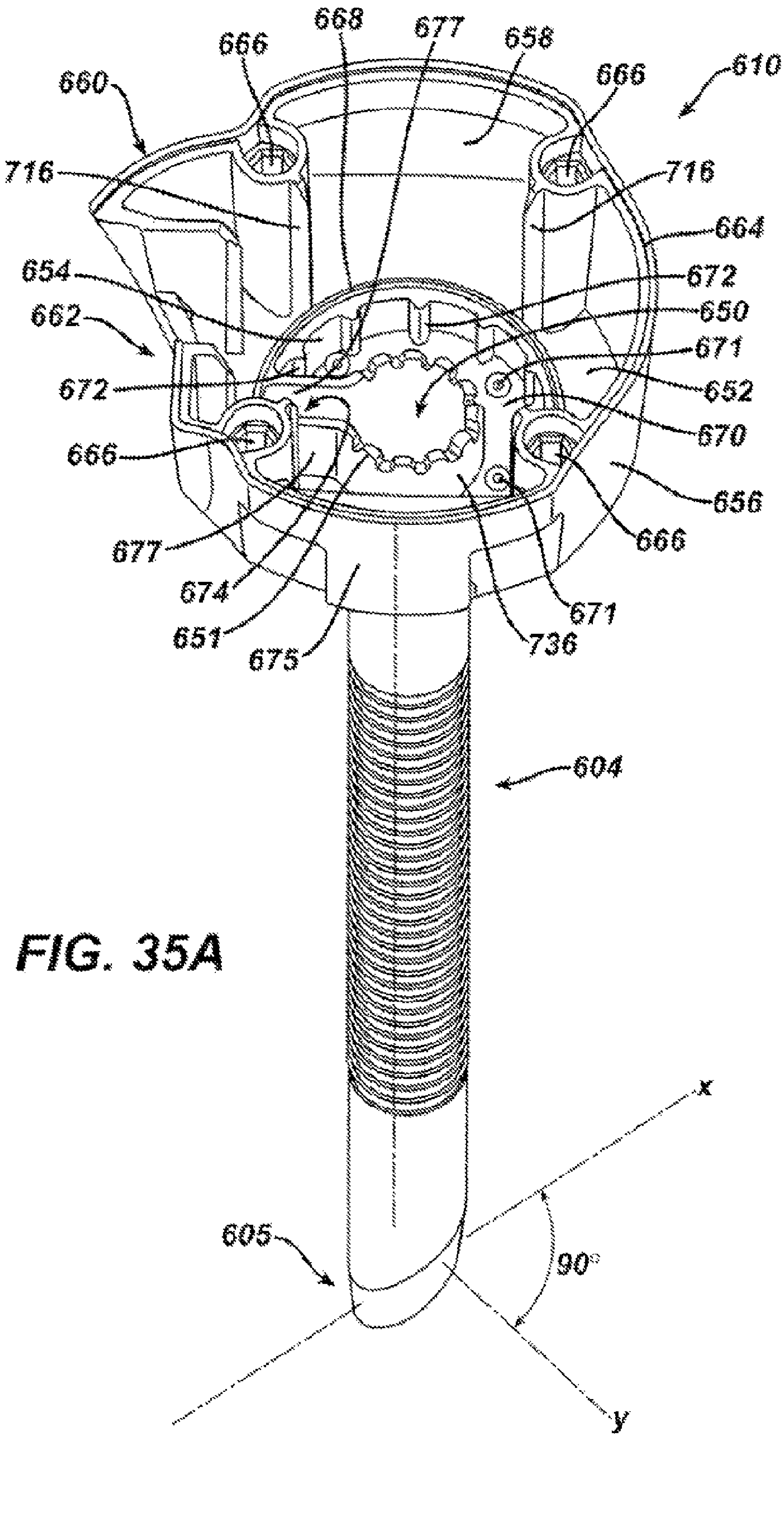
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FIG. 35A

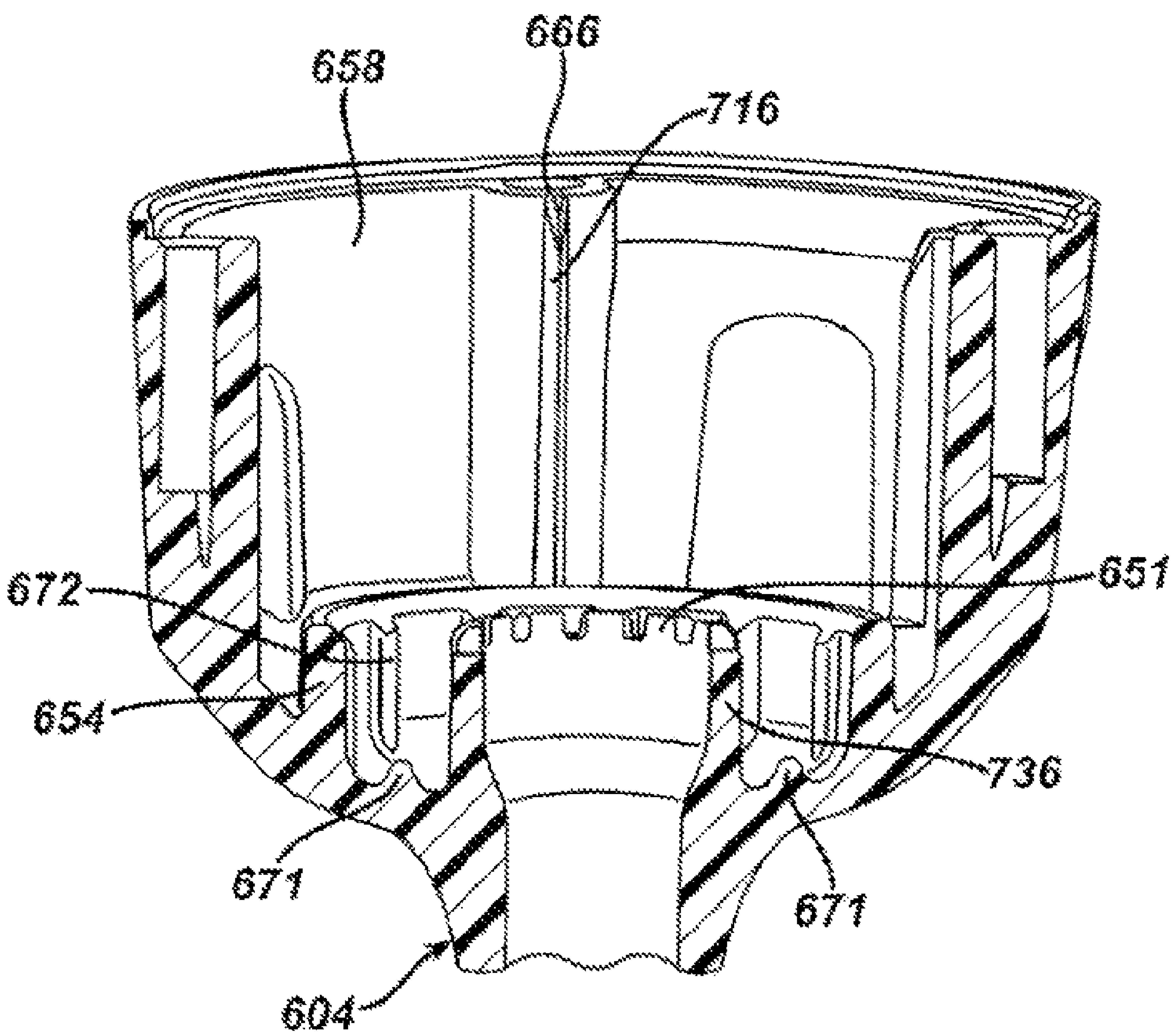

FIG. 35B

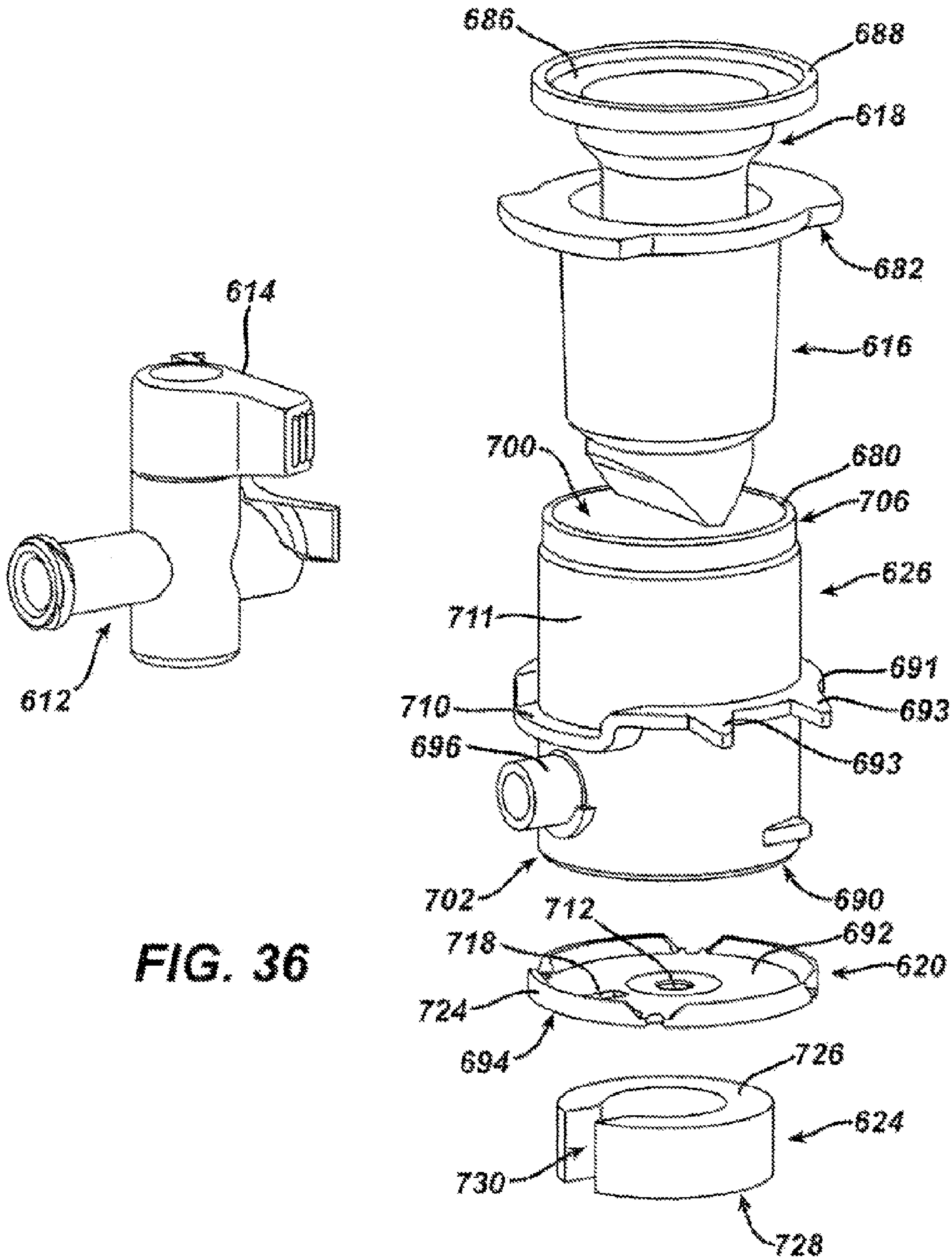
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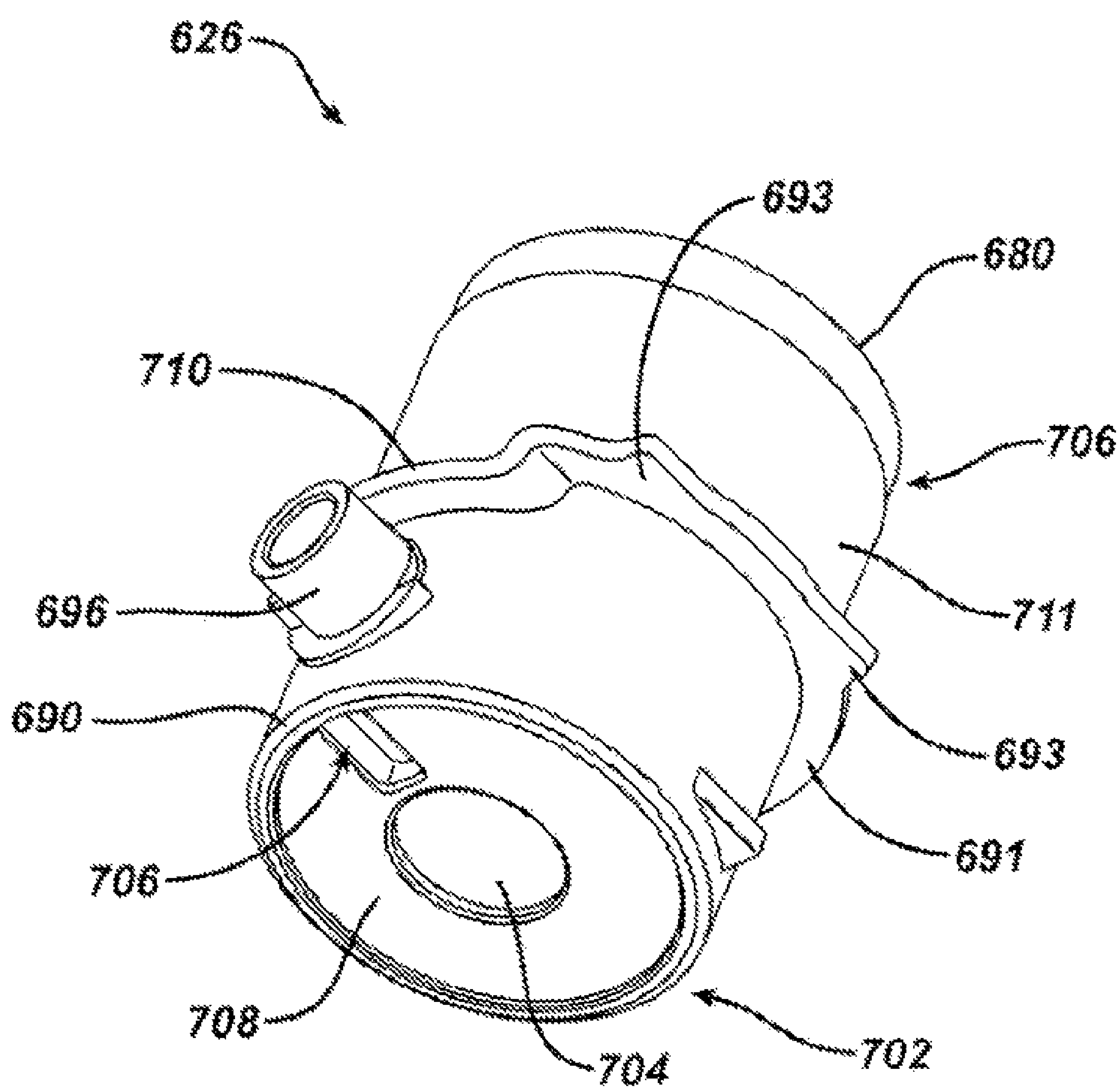
FIG. 36

FIG. 37A



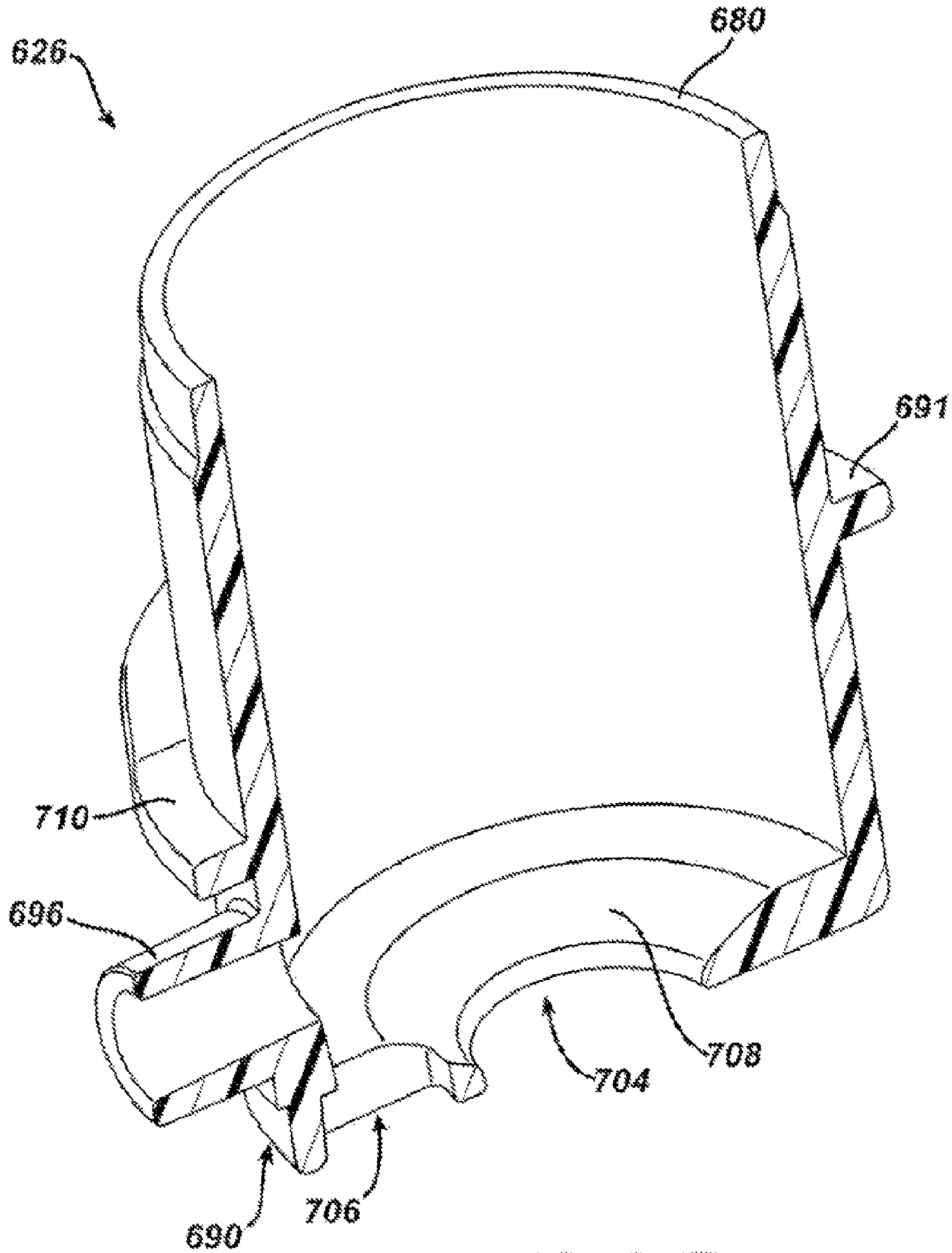
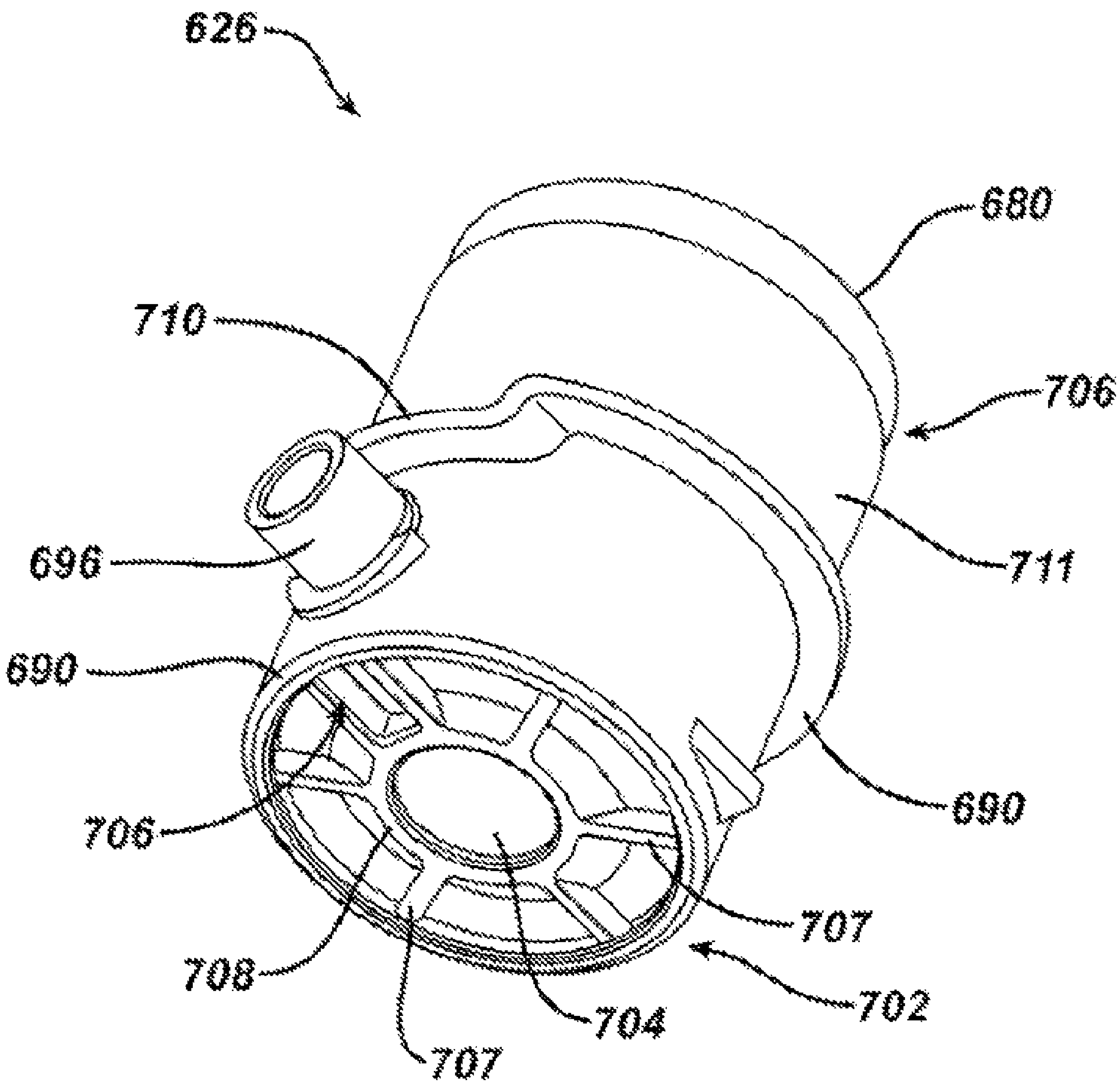


FIG. 37B

FIG. 37C



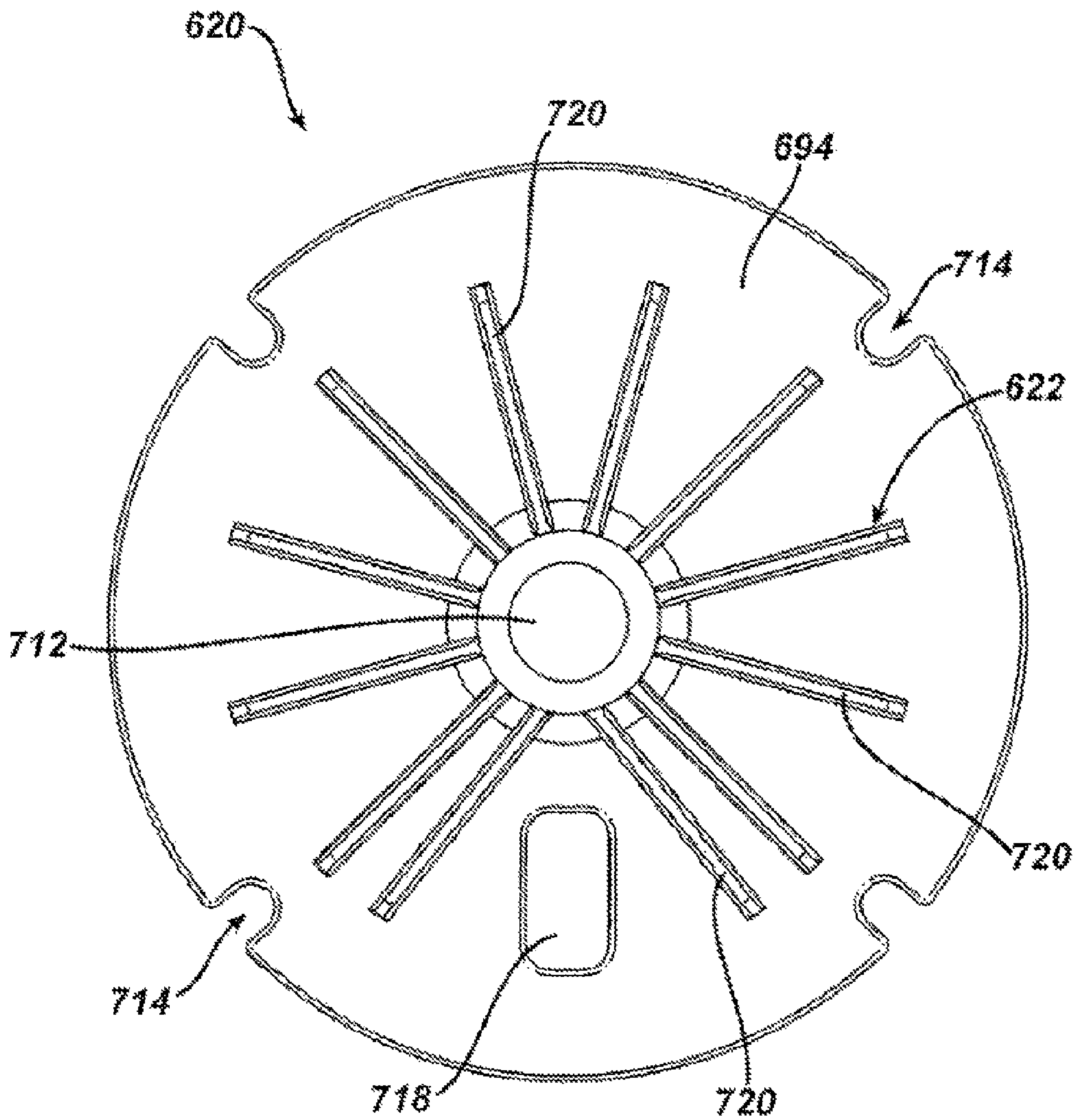


FIG. 38A

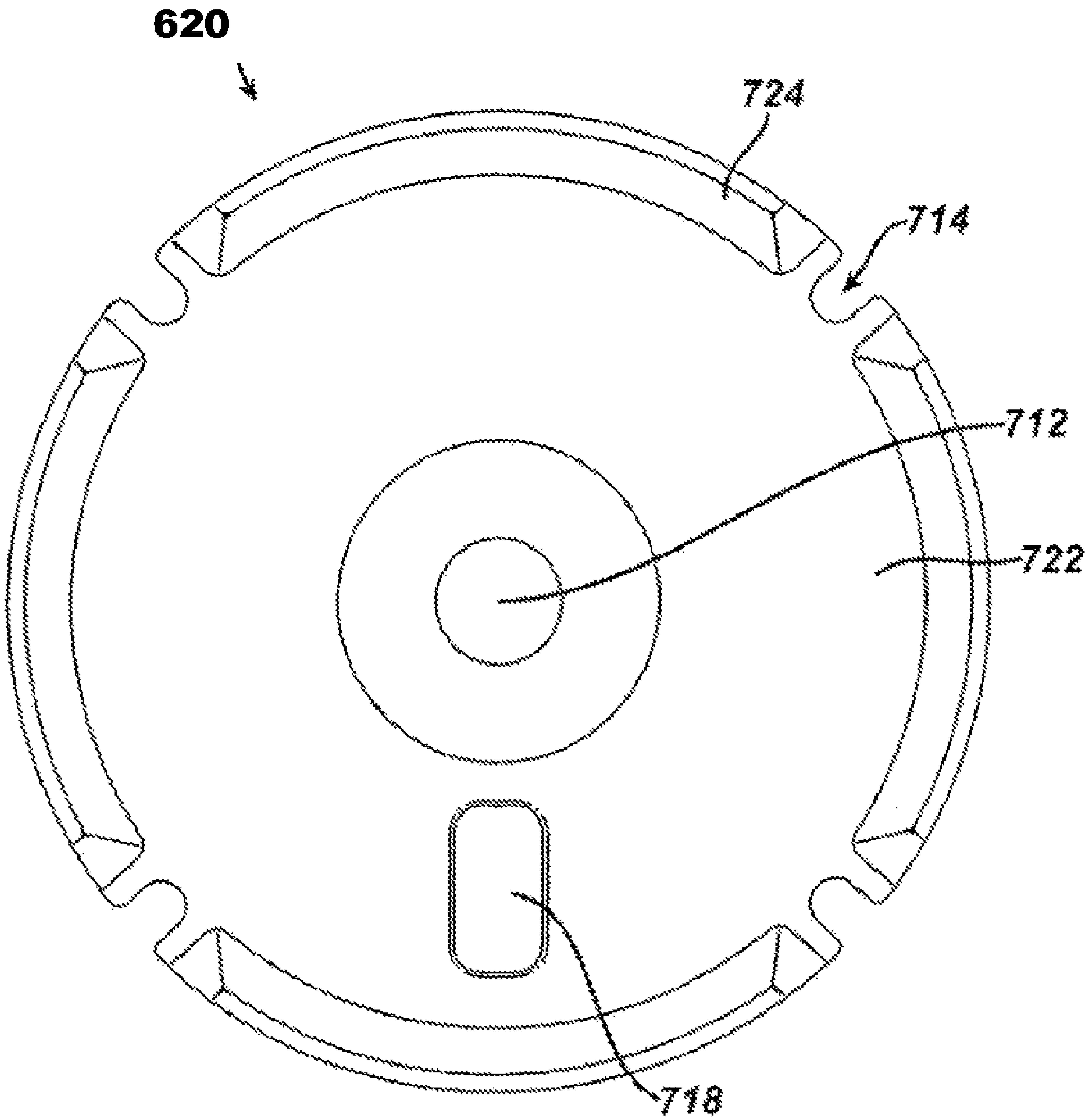


FIG. 38B

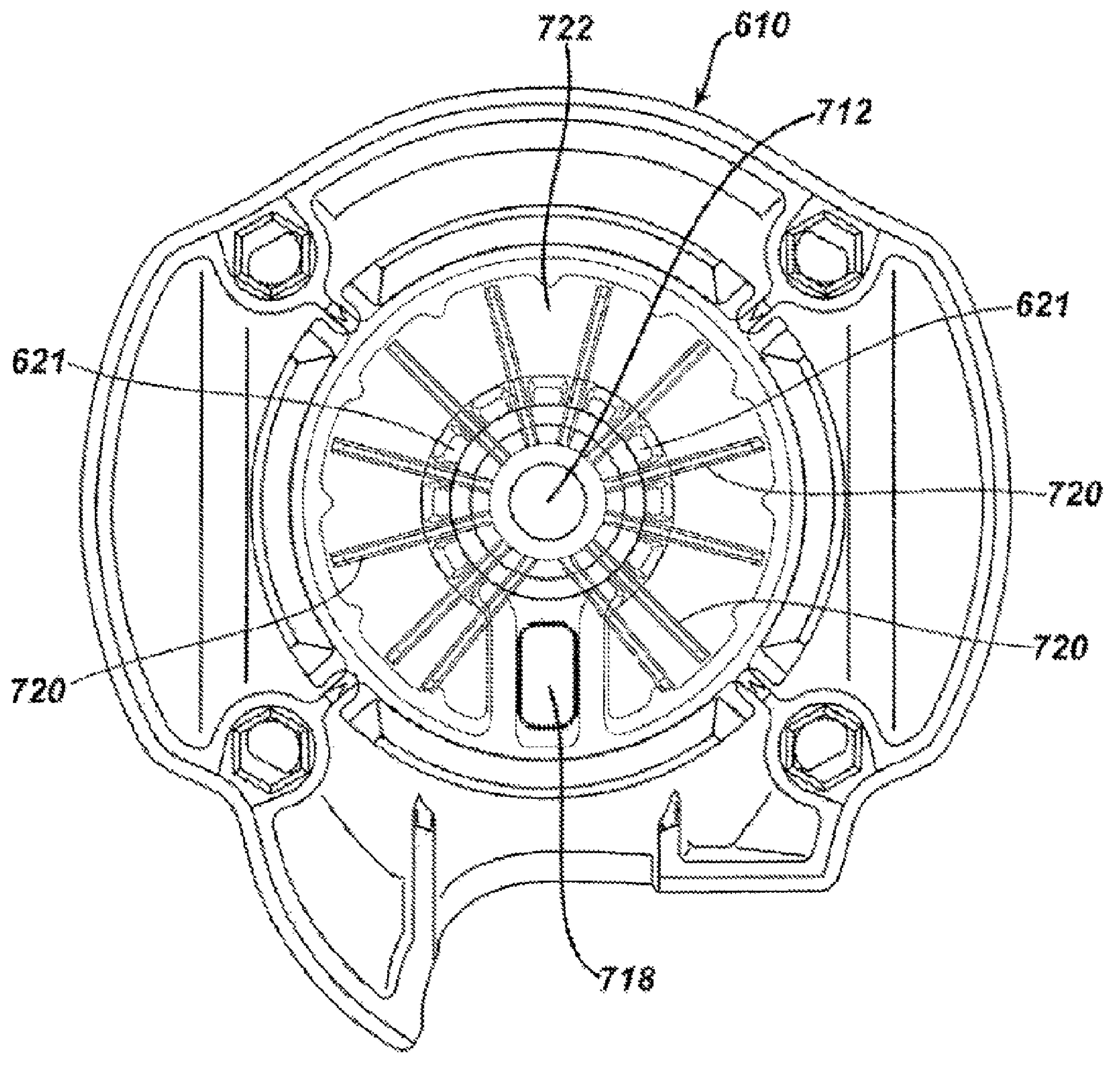


FIG. 38C

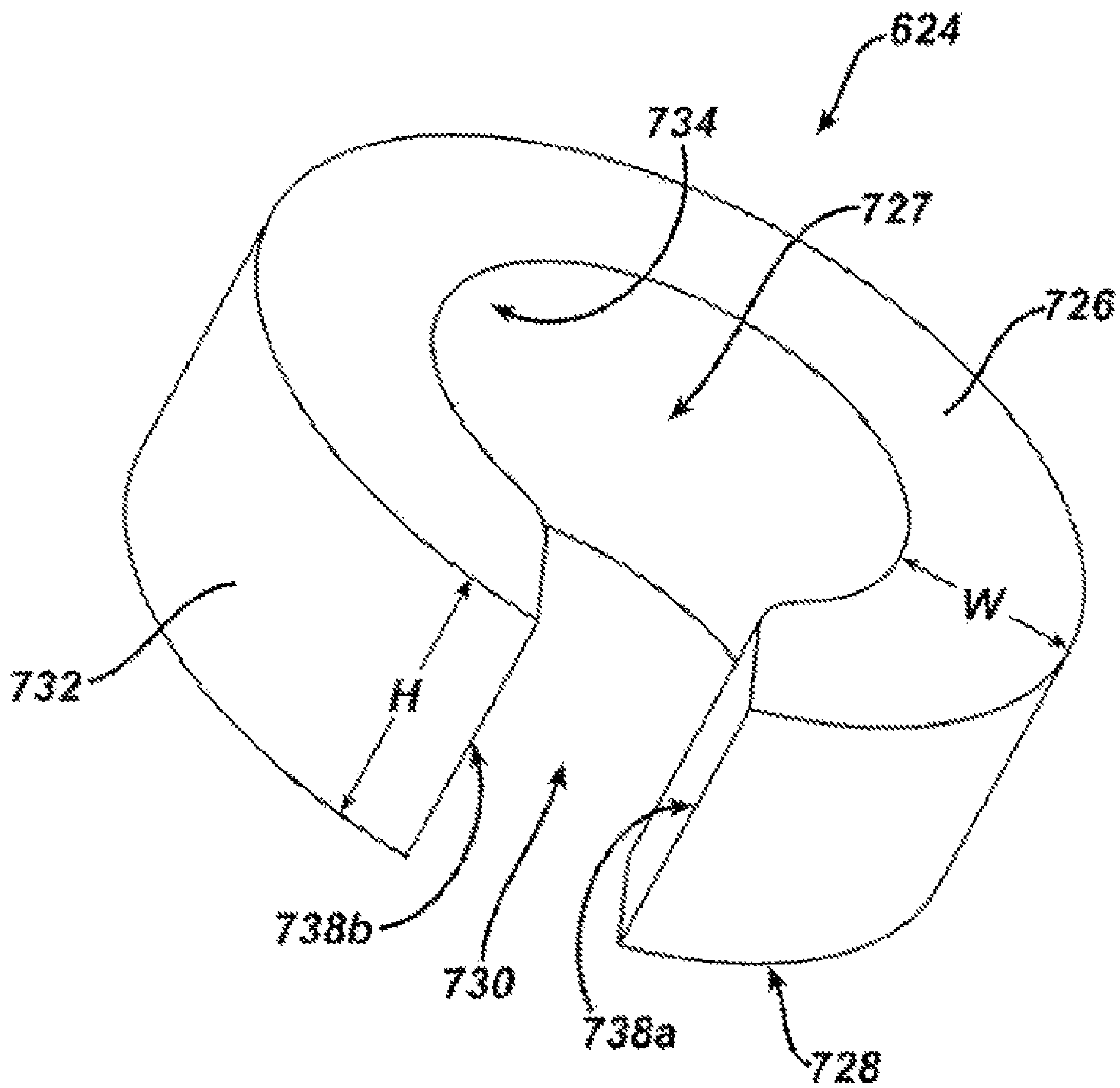


FIG. 39

SURGICAL ACCESS DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/902,265, filed on Oct. 12, 2010 and entitled "Surgical Access Device," which is a continuation-in-part of U.S. patent application Ser. No. 12/533,590 (now U.S. Pat. No. 8,568,362), filed on Jul. 31, 2009 and entitled "Surgical Access Devices with Sorbents," which is a continuation-in-part of: U.S. patent application Ser. No. 12/110,724 (Now U.S. Pat. No. 8,579,807), filed on Apr. 28, 2008 and entitled "Absorbing Fluids in a Surgical Access Device," U.S. patent application Ser. No. 12/110,727, filed on Apr. 28, 2008 and entitled "Scraping Fluid Removal in a Surgical Access Device," U.S. patent application Ser. No. 12/110,742, filed on Apr. 28, 2008 and entitled "Wicking Fluid Management in a Surgical Access Device," and U.S. patent application Ser. No. 12/110,755 (Now U.S. Pat. No. 8,273,060), filed on Apr. 28, 2008 and entitled "Fluid Removal in a Surgical Access Device," all of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to methods and devices for performing surgical procedures, and in particular to methods and devices for maintaining visibility during surgical procedures.

BACKGROUND OF THE INVENTION

During laparoscopic surgery, one or more small incisions are formed in the abdomen and a trocar is inserted through the incision to form a pathway that provides access to the abdominal cavity. The trocar is used to introduce various instruments and tools into the abdominal cavity, as well as to provide insufflation to elevate the abdominal wall above the organs. During such procedures, a scoping device, such as an endoscope or laparoscope, is inserted through one of the trocars to allow a surgeon to view the operative field on an external monitor coupled to the scoping device.

Scoping devices are often inserted and removed through a trocar multiple times during a single surgical procedure, and during each insertion and each removal they can encounter fluid that can adhere to the scopes lens and fully or partially impede visibility through the lens. Furthermore, a scope can draw fluid from inside or outside a patients body into the trocar, where the fluid can be deposited within the trocar until the scope or other instrument is reinserted through the trocar. Upon reinsertion, fluid can adhere to the scopes lens. The scopes lens thus needs to be cleaned to restore visibility, often multiple times during a single surgical procedure. With limited access to a scope in a body, each lens cleaning can require removing the scope from the body, cleaning the scope lens of fluid, and reintroducing the scope into the body. Such lens cleaning is a time-consuming procedure that also increases the chances of complications and contamination through repeated scope insertion and removal.

Accordingly, there is a need for methods and devices for maintaining clear visibility through a lens of a scoping device during a surgical procedure.

SUMMARY OF THE INVENTION

The present invention generally provides methods and devices for preventing fluid deposit onto and/or for removing fluid from a surgical instrument. In one embodiment, a surgical access device is provided and can include a housing defining a working channel sized and configured to receive a surgical instrument. An insufflation port can be formed in the housing and it can be configured to deliver an insufflation gas to the working channel. Further, a seal can be disposed within the housing and it can be positioned proximal to the insufflation port. In some embodiments, the seal can be configured to receive a surgical instrument passed through the working channel.

A fluid remover can be disposed within the housing and it can be positioned distal to the insufflation port. The fluid remover can have many configurations, for example, the fluid remover can have an outer perimeter mounted within the housing and a central opening configured to receive surgical instruments therethrough. In some embodiments, the outer perimeter can be in sealing engagement with the housing. The fluid remover can be configured to allow insufflation gas to pass therethrough when an instrument occludes the central opening. The fluid remover can be, for example, a scraper configured to scrape fluid away from surgical instruments inserted through the central opening.

In some embodiments, the scraper can include a wicking element formed thereon and configured to wick fluid away from the central opening in the scraper. The wicking element can have many different configurations, for example, the wicking element can be in the form of a plurality of channels formed in a distal surface of the scraper and extending radially outward from the central opening such that fluid scraped off of a surgical instrument can flow into the channels. The fluid remover can also include a sorbent disposed distal to the scraper and configured to receive fluid scraped by the scraper. In one embodiment, the fluid remover can include a hole formed therein and positioned a distance away from the central opening and the outer perimeter. The hole can be configured to allow insufflation gas to pass therethrough.

As will be appreciated by those having ordinary skill in the art, the housing can have many configurations. In one embodiment, the housing can include a proximal housing portion and a distal housing portion having a cannula extending distally therefrom. The proximal and distal housing portions can be disposed around an inner retainer, and the working channel can extend through the inner retainer and the cannula. The outer perimeter of the fluid remover can be in sealing engagement with the inner retainer and the distal housing portion. In some embodiments, the seal can be captured between the inner retainer and the proximal housing portion.

The distal cannula can include an angled distal surface having a distal-most point and a proximal-most point. In some embodiments, the distal-most point can be aligned with the insufflation port, although it can have any angular orientation as desired. The surgical access device can also include at least one opening formed on an outside wall of the housing that can be configured for receiving suture.

In other aspects, a surgical access device is provided and can include a housing and a cannula extending distally from the housing. The housing and the cannula can have a working channel extending therethrough between a proximal opening formed in a proximal end of the housing and a distal end of the cannula. The working channel can be sized and configured to receive a surgical instrument. An insufflation port can be coupled to the housing and configured to receive and deliver an insufflation gas to the working channel. Further, a seal can be disposed within the housing and configured to substantially prevent passage of an insufflation gas from the insufflation port to the proximal opening when no surgical instrument is disposed therethrough.

In some embodiments, a fluid remover can be disposed within the housing and can be positioned distal of the seal. The fluid remover can have an outer perimeter in sealing engagement with the housing. The fluid remover can also have a central opening formed therethrough positioned to receive a surgical instrument passed through the working channel. Further, the fluid remover can include a hole formed therein between the central opening and the outer perimeter that is configured to allow insufflation gas to pass from the insufflation port to the cannula when an instrument is disposed through and occludes the central opening in the fluid remover.

While the fluid remover can have many configurations, in one embodiment, the fluid remover can be a scraper configured to scrape fluid off of a surgical instrument passed through the opening. The surgical access device can also include a sorbent disposed within the housing at a location distal to the scraper. The sorbent can be configured to sorb fluid removed by the scraper. In some embodiments, the surgical access device can further include a wicking element formed on the scraper and configured to wick fluid away from the central opening in the scraper. The sorbent can have, for example, a central opening formed therethrough and can be axially aligned with the central opening in the scraper. In one embodiment, the central opening in the sorbent can have a diameter greater than a diameter of the central opening in the scraper. The insufflation port can be positioned anywhere within the housing, for example, the insufflation port can be positioned proximal to the fluid remover.

While the housing can have many configurations, in one embodiment, the housing can include a proximal housing portion and a distal housing portion disposed around an inner retainer. The working channel can extend through the inner retainer, and the outer perimeter of the fluid remover can be in sealing engagement with the inner retainer. The proximal opening can be formed in the proximal housing. In some embodiments, the inner retainer can be captured between the proximal and distal housing portions.

In further aspects, methods are also provided. For example, a method for removing fluid from a surgical access device is provided and can include inserting a surgical access device through tissue such that the surgical access device provides a working channel extending through the tissue and into a body cavity. Further, a surgical instrument can be inserted through the working channel of the surgical access device such that a central opening formed in a scraper disposed within the working channel engages a circumference of the surgical instrument. The method can further include delivering an insufflation gas through an insufflation port in the surgical access device to insufflate the body cavity. The insufflation gas can pass through a hole formed in the scraper.

In some embodiments, inserting a surgical instrument through the working channel of a surgical access device can include inserting a surgical instrument through a seal in a working channel of a surgical access device extending into a body cavity. The seal can move from a closed position in which the working channel is sealed to an open position as the surgical instrument is passed therethrough. Further, a fluid remover disposed distal of the seal can scrape fluid from the surgical instrument and invert proximally to transfer the fluid away from the surgical instrument. Fluid scraped by the scraper can be transferred to a sorbent.

In other aspects, a method for reprocessing a surgical access device is provided and includes removing a scraper from a surgical access device, cleaning the scraper, treating a surface of the scraper with a surfactant, and replacing the scraper in the surgical access device. In some embodiments, the surfactant can be dodecylbenzene sodium sulfonate or sodium dodecyl sulfate. In other embodiments, the scraper can be formed from a hydrophobic material such as a polyisoprene.

In still further aspects, a method for reprocessing a surgical access device is provided and includes removing a first sorbent from a surgical access device, treating a second sorbent with a surfactant, and replacing the first sorbent with the second sorbent in the surgical access device. In some embodiments, the surfactant can be dodecylbenzene sodium sulfonate or sodium dodecyl sulfate.

In another aspect, a fluid remover for use in a surgical access device is provided and can include a housing defining a working channel sized to receive a surgical instrument, an insufflation port disposed in the housing, and a seal disposed proximal to the insufflation port. In some embodiments, the fluid remover can include a fluid removing member having an outer perimeter and a central opening formed therein for receiving and sealing around a surgical access device. The fluid removing member can also have a hole disposed radially outward from the central opening and radially inward from the outer perimeter and can be configured to allow insufflation gas to pass therethrough.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1**A is a perspective view of one embodiment of a trocar;

FIG. **1**B is an exploded view of the trocar of FIG. **1**A;

FIG. **1**C is a cross-sectional view of a portion of the trocar of FIG. **1**A;

FIG. **1**D is a bottom perspective view of an instrument seal assembly for use with the trocar of FIG. **1**A;

FIG. **1**E is an exploded view of the instrument seal assembly of FIG. **1**D;

FIG. **1**F is a perspective view of a channel seal of the trocar of FIG. **1**A;

FIG. **1**G is a bottom perspective view of one embodiment of a scraper of a fluid remover assembly for use with the trocar of FIG. **1**A;

FIG. **1**H is a perspective view of one embodiment of a sorbent wick of a fluid remover assembly for use with the trocar of FIG. **1**A;

FIG. **1**I is a perspective view of a sorbent element of a fluid remover assembly for use with the trocar of FIG. **1**A;

FIG. **1**J is a perspective view of a frame for housing the sorbent element of FIG. **1**I;

FIG. **1**K is a perspective view of a lid portion of a fluid remover assembly for use with the trocar of FIG. **1**A;

FIG. **2**A is a cross-sectional view of a proximal portion of another embodiment of a trocar;

FIG. **2**B is an exploded view of the trocar of FIG. **2**A;

FIG. **3**A is an exploded view of a portion of a trocar having a drop-in fluid remover assembly;

FIG. **3**B is an exploded view of the drop-in fluid remover assembly of FIG. **3**A;

FIG. **3**C is a cross-sectional view of a trocar of FIG. **3**A;

FIG. **4**A is an exploded view of one embodiment of a scraper assembly for scraping fluid;

FIG. 4B is a bottom perspective view the scraper assembly of FIG. 4A;

FIG. 4C is a top perspective view of the scraper assembly of FIG. 4A;

FIG. 5A is a perspective view of another embodiment of fluid remover assembly having a scraper nested within a sorbent element;

FIG. 5B is top view of the fluid remover assembly of FIG. 5A;

FIG. 5C is a cross-sectional view of the fluid remover assembly of FIG. 5A disposed within a trocar housing;

FIG. 6A is a cross-sectional view of a trocar having one embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 6B is a cross-sectional view of a trocar having another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 6C is a cross-sectional view of a trocar having yet another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 7 is a cross-sectional view of another embodiment of a trocar housing having sorbent flapper doors positioned adjacent to a zero-closure seal;

FIG. 8 is a cross-sectional view of yet another embodiment of a trocar housing having wicking fingers coupled to a sorbent reservoir;

FIG. 9 is a cross-sectional view of one embodiment of a trocar housing having a sorbent element disposed therein;

FIG. 10A is a cross-sectional view of one embodiment of a zero-closure seal having extension members for wicking fluid;

FIG. 10B is a transparent perspective view of the seal of FIG. 10A;

FIG. 11 is an exploded view of another embodiment of fluid remover assembly having a sorbent element nested between first and second zero-closure seals;

FIG. 12A is a cross-sectional view of yet another embodiment of a sorbent element having two sorbent bars disposed within a zero-closure seal;

FIG. 12B is a transparent perspective view of the sorbent element and seal of FIG. 12A;

FIG. 13 is an exploded view of one embodiment of a trocar housing having a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 14 is a cross-sectional view of one embodiment of a trocar cap having a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 15A is a top view of a trocar cap having another embodiment of a scraper for scraping fluid away from a surgical instrument passed therethrough;

FIG. 15B is a side perspective view of the trocar cap of FIG. 15A;

FIG. 16 is an exploded view of one embodiment of a multi-layer seal having a sorbent element disposed between the layers;

FIG. 17 is a bottom perspective view of one embodiment of a trocar cap having a sorbent element disposed therein;

FIG. 18A is a bottom perspective view of one embodiment of a wicking element formed on a portion of a seal protector for creating between the seal protector and a seal;

FIG. 18B is a top perspective view of the portion of the seal protector of FIG. 18A;

FIG. 19A is a top view of a multi-layer protective member having camming ribs;

FIG. 19B is a top view of one layer of the protective member of FIG. 19A;

FIG. 20A is a side perspective view of a deep cone instrument seal having wicking ribs formed on an external surface;

FIG. 20B is a top perspective view of another embodiment of a deep cone instrument seal having wicking ribs formed on an internal surface;

FIG. 21 is a perspective view of a multi-layer protective element having holes formed therein for receiving fluid;

FIG. 22A is an exploded view of a multi-layer protective element;

FIG. 22B is a cross-sectional view taken across line B-B of one of the protective elements of FIG. 22A;

FIG. 23A is a side view of one embodiment of a seal having an hourglass configuration for scraping fluid off of a surgical instrument;

FIG. 23B is a side view of the seal of FIG. 23A showing an instrument passed therethrough;

FIG. 24A is cross-sectional view of one embodiment of a trocar cannula having overlapping scrapers and a sorbent disposed therein;

FIG. 24B is an enlarged view of one of the scrapers and sorbents of FIG. 24A;

FIG. 25 is a perspective view of another embodiment of a scraper for scraping fluid off of a surgical instrument shown passed therethrough;

FIG. 26 is a perspective view of another embodiment of a device for scraping fluid away from a surgical instrument;

FIG. 27A is an exploded view of a trocar and removable tip for scraping fluid away from a surgical instrument;

FIG. 27B is an assembled side view of a distal end of the trocar and removable tip of FIG. 27A;

FIG. 27C is a perspective view of the removable tip and distal end of the trocar of FIG. 26B;

FIG. 28 is a partially-transparent side view of one embodiment of wicking element having an hourglass shape;

FIG. 29 is a perspective view of a trocar having a cannula with slots formed therein for wicking fluid out of the cannula;

FIG. 30A is a perspective view of another embodiment of a trocar having a proximal housing and a distal cannula;

FIG. 30B is a cross-sectional side view of the trocar of FIG. 30A;

FIG. 30C is a perspective view of an instrument seal assembly, a channel seal, a fluid remover assembly, and an insufflation port of the trocar of FIG. 30A;

FIG. 30D is a cross-sectional side view of the fluid remover and insufflation port of FIG. 30C;

FIG. 30E is a perspective view of a fluid remover of FIG. 30C;

FIG. 30F is an exploded view of the fluid remover of FIG. 30E showing a lid, scraper, crown, and sorbent;

FIG. 30G is a bottom perspective view of a scraper of FIG. 30F showing channels formed therein;

FIG. 30H is a cross-sectional view of one of the channels of the scraper of FIG. 30G;

FIG. 30I is a top view of a lid of FIG. 30F;

FIG. 30J is a bottom view of the lid of FIG. 33I; and

FIG. 31 is a bottom view of another embodiment of a lid for use with a fluid remover assembly;

FIG. 32A is a perspective view of another embodiment of a trocar;

FIG. 32B is a side perspective view of an instrument seal, a channel seal, a fluid remover, and an insufflation port of the trocar of FIG. 32A;

FIG. 32C is a side view of the fluid remover and insufflation port of FIG. 32B;

FIG. 32D is a side perspective view of the fluid remover of FIG. 32C;

FIG. 33A is a perspective view of another embodiment of a trocar having a fluid removing system disposed therein;

FIG. 33B is a cross-sectional view of the trocar of FIG. 33A showing an exemplary seal system and fluid removal system;

FIG. 34A is a perspective view of one embodiment of a proximal housing of the trocar of FIG. 33A;

FIG. 34B is another perspective view of the proximal housing of FIG. 34A;

FIG. 35A is a perspective view of one embodiment of a distal housing of the trocar of FIG. 33A;

FIG. 35B is a perspective cross-sectional view of the distal housing of FIG. 35A;

FIG. 36 is an exploded view of the seal system and fluid removal system of the trocar of FIG. 33A;

FIG. 37A is a perspective view of an exemplary seal retainer of the trocar of FIG. 33A;

FIG. 37B is a cross-sectional view of the seal retainer of FIG. 37A;

FIG. 37C is a perspective view of another exemplary seal retainer for use in the trocar of FIG. 33A;

FIG. 38A is a bottom view of an exemplary scraper and wicking element for use in the trocar of FIG. 33A;

FIG. 38B is a top view of the scraper of FIG. 38A;

FIG. 38C is a top view of the scraper of FIG. 38A seated within an exemplary distal housing; and

FIG. 39 is a perspective view of an exemplary sorbent for use in the trocar of FIG. 33A.

DETAILED DESCRIPTION OF THE INVENTION

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those skilled in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

The present invention generally provides methods and devices for maintaining clear visibility through a scoping device during surgical procedures, and in particular methods and devices are provided for removing fluid from an access device and/or surgical instrument passed, e.g., inserted and/or withdrawn, through an access device, and/or for preventing fluid from being transferred onto a scoping device passed through an access device. In certain exemplary embodiments, the methods and devices are effective to remove fluid from an access device and/or surgical instrument as the instrument is being withdrawn from the access device, thus preventing the fluid from being deposited onto an instrument being inserted through the access device. However, the methods and devices can be configured to remove fluid prior to and/or during insertion and/or removal.

A person skilled in the art will appreciate that the term fluid as used herein is intended to include any substance that, when on a surgical instrument, can adversely affect the functioning of the instrument or a surgeon's ability to use it. Fluids include any kind of bodily fluid, such as blood, and any kind of fluid introduced during a surgical procedure, such as saline. Fluids also include fluid/solid mixtures or fluids with particles (such as pieces of tissue) suspended or located therein, as well as viscous materials and gases. A person skilled in the art will also appreciate that the various concepts disclosed herein can be used with various surgical instruments during various procedures, but in certain exemplary embodiments the present invention is particularly useful during laparoscope procedures, and more particularly during procedures in which a scoping device, such as an laparoscope or endoscope, is passed through a surgical access device, such as a trocar, that provides a pathway from a skin incision to a body cavity. As previously explained, during such procedures repeated insertion and withdrawal of the scoping device can deposit fluid within the access device, thus allowing the fluid to be transferred back onto the distal viewing end of the scoping device upon reinsertion therethrough. Various exemplary methods and devices are provided herein to prevent such an occurrence.

In certain exemplary embodiments, the methods and devices disclosed herein utilize a fluid remover that is effective to remove fluid from an access device and/or surgical instrument passed therethrough. While the fluid remover can have various configurations and it can function in various manners to remove fluid, exemplary fluid removers include scrapers for scraping fluids, sorbents for sorbing fluid, and wicking elements for redirecting or wicking fluid away, e.g., by capillary action. Any combination of fluid removers can be provided, and the fluid removers can be disposed at various locations within an access device to remove fluid from portions of the access device and/or from surgical instruments, such as scoping devices, passed through the access device. The particular location of the fluid remover(s) can depend on the particular configuration of the access device and/or surgical instrument.

In certain exemplary embodiments, the fluid remover can include one or more sorbents. The sorbent can be any insoluble (or at least partially insoluble) material or mixture of materials that are capable of sorbing fluids or taking up fluids through a process of one or both of absorption and adsorption. A sorbent material or element can thus include any one of or combination of absorbent materials and/or elements and adsorbent materials and/or elements. In certain exemplary embodiments, the sorbent is formed from a hydrophilic material and/or includes a hydrophilic material to facilitate fluid receipt. For example, the sorbent can be coated using known coating techniques during manufacturing to render one or more portions of the sorbent hydrophilic. In one embodiment, the sorbent can be formed by an extrusion process in which, for example, the fibers can all extend longitudinally in a direction generally parallel to a longitudinal axis of the cylindrical tube, as shown in FIG. 30F. The fibers will thus form a generally cylindrical, hollow tubular member, which can subsequently be cut to form a plurality of sorbents. A sidewall gap or cut-out can also be made to form a C-shaped sorbent, or the sorbent can be formed to have a C-shaped configuration without the need to make any additional cuts. Exemplary shapes and configurations for the sorbent will be discussed in more detail below. A hydrophilic surfactant can be applied to the sorbent, either prior to or after the sorbent is cut. A person skill in the art will appreciate that a variety of techniques can be used to coat the sorbent or portions thereof with a hydrophilic material and/or to form the sorbent or portions thereof from a hydrophilic material. The particular hydrophilic material used can also vary, and exemplary materials will be discussed in more detail below with respect to the scraper. The same hydrophilic materials used with the scraper can also or alternatively be used with the sorbent.

In general, sorbents that are absorbents remove fluid through a process of absorption, similar to a sponge, in which a liquid diffuses into the volume and/or structure of the absorbent and becomes a part of that volume and/or structure. For example, the sorbent can pick up and retain a liquid distributed throughout its molecular structure causing the absorbent to swell. The liquid can cause the solid structure to swell 50% of more. Typical absorbents are at least 70% insoluble in excess fluid. Absorbents can have any shape, size, and form known in the art as needed to stand alone and/or fit within, around, or throughout any component of a fluid remover and/or trocar. Certain exemplary embodiments of absorbents include, but are not limited to, comminuted wood pulp fluff, cellulose fibers, polymeric gelling agents, hydrophilic non-wovens, cellulose, sodium polycrylate, cotton, polyethylene terephthalate, polyethylene, polypropylene, polyvinyl chloride, ABS, polyamide, polystyrene, polyvinyl alcohol, polycarbonate, ethylene-methacrylate copolymer, and polyacetal.

Sorbents that are adsorbents, on the other hand, remove fluid through a process of adsorption by retaining a liquid on their surface including pores and capillaries. Liquid accumulates on the surface of an adsorbent by forming a film of molecules or atoms that are retained thereon as a consequence of surface energy. In some embodiments, an adsorbent material can include one or more insoluble materials (or at least partially insoluble) that can be coated by a liquid on their surface. For example, the adsorbent can be a structure formed from insoluble fibers. The structure can be porous, as voids or spaces can be located between the individual fibers. Thus, liquid can accumulate on the surface of the fibers, thereby filling the voids between the fibers. Typical adsorbents will adsorb fluid without swelling more than 50% in excess liquid. Adsorbents can have any shape, size, and form known in the art as needed to stand alone and/or fit within, around, or throughout any component of a fluid remover and/or trocar. In an exemplary embodiment, the adsorbent is molded to have a predetermined shape and size. Certain exemplary adsorbent materials include, but are not limited to, oxygen-containing compounds, carbon-based compounds, and/or polymer based compounds, among others. For example, adsorbent materials can include silica gels, alumina, zeolites, activated carbon, graphite, cellulose, porous polymer matrices, perlite, metal hydroxides, metal oxidesellulose acetate, -butyrate and -nitrate, polyamide, polysulfone, vinyl polymers, polyesters, polyolefines and PTFE, as well as porous glass or glass ceramics, graphite oxide, polyelectrolyte complexes, alginate gel, etc.

While the fluid removers disclosed herein can be used with various surgical access devices known in the art, in certain exemplary embodiments a trocar is provided having one or more fluid removers disposed therein for removing fluid from portions of the trocar and/or from an instrument, such as a scoping device, passed therethrough. A person skilled in the art will appreciate that a trocar is shown for illustration purposes only, and that virtually any type of access device, including cannulas, ports, etc., can be used. FIGS. **1A**-**1C** illustrate one exemplary embodiment of a trocar **2**. As shown, the trocar **2** is generally in the form of a housing **6** having a proximal portion (also referred to herein as a proximal housing) that can house one or more sealing elements and a distal cannula **8** extending distally from the proximal housing **6**. The trocar **2** defines a working channel **4** extending therethrough for introducing various instruments into a body cavity. A number of configurations are available for the proximal housing **6**. In the illustrated embodiment, the proximal housing **6** has a generally cylindrical shape with a removable cap portion **5** and an inner sidewall **3**. An opening **7** can be formed in the proximal end of the housing **6**, such that the opening **7** extends through the removable cap **5** and through the remainder of the housing **6** and is coaxial with the working channel **4** extending through the cannula **8**. The cannula **8** can also have various configurations, and can include various features known in the art. In the illustrated embodiment, the cannula **8** has a generally elongate cylindrical shape and includes a series of annular ridges **9** formed on an external surface **10** thereof. The opening **7** extending through the proximal housing **6** and the cannula **8** define the working channel **4** that is sized and configured to receive a surgical instrument. One skilled in the art will appreciate that the housing **6** and the cannula **8** can be formed as a unitary structure or as two separate components that are mated to one another. The housing **6** can also include other features, such as a stop-cock valve **13** for allowing and preventing the passage of an insufflation fluid, e.g. carbon dioxide, through the trocar **2** and into a body cavity.

In use, the distal cannula **8** can be inserted through a skin incision and through tissue to position a distal-most end within a body cavity. The proximal housing **6** can remain external to the body cavity, and various instruments can be inserted through the working channel **4** and into the body cavity. Typically, during surgical procedures in a body cavity, such as the abdomen, insufflation is provided through the trocar **2** to expand the body cavity to facilitate the surgical procedure. Thus, in order to maintain insufflation within the body cavity, most trocars include at least one seal disposed therein to prevent air from escaping. Various seal configurations are known in the art, but typically the trocar **2** includes an instrument seal that forms a seal around an instrument disposed therethrough, but otherwise does not form a seal when no instrument is disposed therethrough; a channel seal (also referred to herein as a zero-closure seal) that seals the working channel **4** when no instrument is disposed therethrough; or a combination instrument seal and channel seal that is effective to both form a seal around an instrument disposed therethrough and to form a seal in the working channel **4** when no instrument is disposed therethrough. In the embodiment shown in FIGS. **1A**-**1C** the trocar **2** includes an instrument seal **14** and a separate channel or zero-closure seal **24**. However, a person skilled in the art will appreciate that various other seals known in the art can be used including, for example, flapper valves, gel seals, diaphragm seals, etc.

In an exemplary embodiment, as shown in FIGS. **1C**-**1E**, the instrument seal **14** is generally in the form of a multi-layer conical seal **16** and a multi-layer protective member **18** disposed on a proximal surface **15** of the seal **16**. As best shown in FIG. **1E**, the multi-layer conical seal **16** can include a series of overlapping seal segments **20** that are assembled in a woven arrangement to provide a complete seal body. The seal segments **20** can be stacked on top of one another or woven together in an overlapping fashion to form the multi-layer seal **16** having a central opening **17** therein. The seal segments **20** can be made from any number of materials known to those skilled in the art, but in an exemplary embodiment the seal segments **20** are formed from an elastomeric material. The seal segments **20** can also be molded such that they have a varying thickness across the profile of the seal **16**. Varying the thickness across to the profile of the seal **16** can be effective to minimize leakage and reduce drag forces on the instrument. The multi-layer protective member **18** can similarly be formed from a series of overlapping segments **22** that are disposed proximal to the overlapping seal segments **20** and that are configured to protect the seal segments **20** from damage caused by surgical instruments passed through the opening **17** in the seal **16**. The protective member **18** can also be formed from various materials, but in certain exemplary embodiments the protective member **18** is formed from a molded thermoplastic polyurethane elastomer, such as Pellethane™. The segments **20**, **22** that form the seal **16** and the protective member **18** can be held together using various techniques known in the art. As shown in FIGS. **1**D and **1**E, the segments **20**, **22** are held together by several ring members that mate to engage the segments **20**, **22** therebetween. In particular, the protective member **18** is engaged between a crown **26** and a gasket ring **28**, and the seal **16** is engaged between the gasket ring **28** and a retainer ring **30**. Pins **32** are used to mate the ring members **26**, **28** and to extend through and engage the segments of the seal **16** and protective member **18**.

When fully assembled, the instrument seal **14** can be disposed at various locations within the trocar **2**. In the illustrated embodiment, the instrument seal **14** is disposed in the cap **5** of the trocar **2** at a location just distal of the proximal opening **7** and proximal of a channel seal, as discussed in more detail below. In use, an instrument can be passed through the center of the seal assembly and the seal segments **20**, **22** can engage and form a seal around an outer surface of the instrument to thereby prevent the passage of fluids through the seal **14**. When no instrument is disposed therethrough, the opening will not form a seal in the working channel **4**, however other configurations in which a seal is formed when no instrument is disposed therethrough are also conceivable. Exemplary instrument seal configurations are described in more detail in U.S. Publication No. 2004/0230161 entitled "Trocar Seal Assembly," filed on Mar. 31, 2004, and U.S. application Ser. No. 10/687,502 entitled "Conical Trocar Seal," filed on Oct. 15, 2003, which are hereby incorporated by reference in their entireties.

The zero-closure seal in the illustrated embodiment is shown in more detail in FIG. **1**F, and as shown the illustrated zero-closure seal is in the form of a duckbill seal **24**. The seal **24** is configured to form a seal in the working channel **4** when no instrument is disposed therethrough to thus prevent the leakage of insufflation gases delivered through the trocar **2** to the body cavity. As shown, the duckbill seal **24** has a generally circular flange **34** with a sidewall **36** extending distally therefrom. The shape of the sidewall **36** can vary, but in the illustrated embodiment, the sidewall **36** includes opposed flaps **35** that extend at an angle toward one another in a distal direction and that come together at a distal end to form a seal face **38**. The opposed flaps **35** are movable relative to one another to allow the seal face **38** to move between a closed position, in which no instrument is disposed therethrough and the seal face **38** seals the working channel **4** of the trocar **2**, and an open position in which an instrument is disposed therethrough. The seal can include various other features, as described in more detail in U.S. application Ser. No. 11/771,263, entitled "Duckbill Seal with Fluid Drainage Feature," filed on Jun. 29, 2007, which is hereby incorporated by reference in its entirety.

In accordance with the present disclosure the general structure of the seals as well as the trocar do not generally form part of the present invention. As such, a person skilled in the art will certainly appreciate that various seal configurations, as well as various trocars, can be used without departing from the spirit of the invention disclosed herein.

As indicated above, a fluid remover can be disposed within the trocar **2** to remove fluid from a seal and/or from a surgical instrument extending through the seal. As best shown in FIGS. **1**B-**1**C, the illustrated trocar **2** includes a fluid remover assembly **40** that is disposed within the proximal housing **6** of the trocar **2** at a location distal of the duckbill seal **24**. The fluid removal assembly **40** includes a scraper for scraping fluid off of a surgical instrument passed through the working channel **4** in the trocar **2**, and a sorbent for sorbing removed fluid. The scraper can also include a wicking feature for wicking fluid away from the opening in the scraper, and/or the sorbent can include a wicking feature for wicking fluid away from the scraper.

The components of the fluid remover assembly **40** are shown in more detail in FIGS. **1**G-**1**K, and as shown the assembly generally includes a lid **42** (FIG. **1**K), a scraper **44** (FIG. **1**G), a sorbent wick **46** (FIG. **1**H), sorbent cartridges **48** (FIG. **1**I), and a housing or frame **50** (FIG. **1**J). When fully assembled, the fluid remover assembly **40** is configured to scrape fluid off of surgical instruments passing through the working channel **4** of the trocar **2**, to wick the scraped fluids away, and to sorb them, thereby preventing the fluids from being redeposited on the instrument upon reinsertion through the working channel.

Referring first to FIG. **1**G, the scraper **44** can have a variety of configurations, but in an exemplary embodiment, as shown, the scraper has a generally planar configuration with a circular shape. A central opening **52** is formed through a central portion thereof and is sized and configured to receive a surgical instrument therethrough. In use, the central opening **52** can be coaxial with openings in the instrument and channel seals. The scraper **44** can be formed from various materials, but in an exemplary embodiment the scraper is formed from polyisoprene to allow the scraper **44** to engage and scrape fluid off of any instrument passed therethrough. As further shown in FIG. **1**G, a distal-facing surface **54** of the scraper **44** can include a plurality of channels **56** formed therein and extending radially outward from the central opening **52**, or from a location just radially outward but adjacent to the central opening **52**. The channels **56** can be configured such that fluid scraped off of an instrument by the central opening **52** will flow into the channels **56** and thereby be wicked away from the opening **52**.

As indicated above, the fluid remover assembly **40** can also include a sorbent wick **46**. As shown in FIG. **1**H, in an exemplary embodiment the sorbent wick **46** has a generally planar circular portion **62** with a central opening **58** formed therethough. The central opening **58** can have a diameter slightly larger than a diameter of the central opening **52** in the scraper **44**, and it can be configured to be positioned coaxial with the opening **52** in the scraper **44**. As further shown in FIG. **1**H, the sorbent wick **46** can also include one or more sidewalls **60** extending from the planar circular portion **62**. The illustrated sidewalls **60** extend proximally, however they can extend distally depending on the particular configuration of the wick **46**. The sidewalls **60** can be configured to sit within the inner sidewall **3** of the trocar housing **6**. In use, the sorbent wick **46** can wick and sorb fluid away from the central opening **52** in the scraper **44**, and it can deliver the fluid to the sorbent cartridges **48**, as discussed in more detail below. The sorbent wick **46**, as well as various other sorbent members disclosed herein, can be formed from a variety of sorbent materials as described above.

The sorbent cartridges **48** are shown in more detail in FIG. **1**I, and as shown the cartridges **48** each have a generally semi-circular shape with a width, as measured from an internal surface **64** to an external surface **66**, that decreases in a proximal to distal direction to form wedge-shaped members **68**. Together, the cartridges **48** can have an annular configuration. In use, the cartridges **48** can sorb fluid from the sorbent wick **46**, thereby storing the fluid at a location away from any instrument passed through the working channel **4**. The cartridges **48** can be contained within the trocar **2** by a housing or frame **50**, as shown in FIG. **1**J. The frame **50** can have a generally cylindrical configuration with an opening **68** extending therethrough, and a plurality of ridges **70** protruding radially outward and extending axially along an outer surface **72** thereof. Each sorbent cartridge **48** can be seated between two ridges. In use, the frame **50** can be particularly advantageous as it can protect the sorbent from being contacted by instruments passing through the working channel.

When fully assembly, the scraper **44** can be seated within the sorbent wick **46**, which can rest on top of the frame **50** that holds the sorbent cartridges **48**. The lid **42**, shown in FIG. **1**K, can be seated on top of the scraper **44** and within the sorbent wick **46**, and the lid **42** can lock onto the frame **50**, thereby holding the fluid remover assembly **40** together. Referring to FIG. **1**C, the entire assembly **40** can be seated within the proximal housing **6** of the trocar **2** just distal of the duckbill seal **24**. As a result, when an instrument, such as a scoping device, is passed through the working channel **4** of the trocar **2**, any fluid on the instrument will be scraped off of the sidewalls of the instrument by the scraper **44**. The fluid will flow through the channels **56** and/or be wicked away from the opening **52** by the sorbent wick **46**, which delivers the fluid to the sorbent cartridges **48**. As a result, when the instrument is withdrawn, for example, the fluid will be prevented from being deposited onto the instrument seal **14**, thereby preventing the fluid from being transferred from the instrument seal **14** back onto the instrument upon reinsertion.

FIGS. **2**A-**2**B illustrate yet another embodiment of a fluid remover assembly **80** that is similar to the embodiment shown in FIG. **1**A. In this embodiment, the proximal housing **79** of the trocar has a frame **82** that is molded into the inner sidewall **81** of the housing **79** for directly seating a sorbent, a scraper, and a lid, thereby eliminating the need for the frame **50** of FIG. **1**J. A single sorbent element **86** is also provided, rather than a sorbent wick and separate sorbent cartridges. In particular, the sorbent element **86** in this embodiment has a generally cylindrical configuration with a distal portion **88** that tapers inward on an outer surface **87** thereof to conform to the inner surface **81** of the proximal housing **79** of the trocar. A recess **90** can be formed around an inner surface **92** of a proximal end **93** of the sorbent element **86** to seat a scraper **94**, which can have a configuration that is the same as or similar to the scraper **44** described above with respect to FIG. **1**G. The recess **90** can engage an outer perimeter **96** of the scraper **94** such that the channels **56** on the scraper **94** can deliver fluid away from the opening **52** in the scraper **94** to the sorbent element **86** surrounding the scraper **94**. A cap **98** can sit on top of the scraper **94** and can include a flange **99** that extends around the proximal end **93** of the sorbent element **86**. The cap **98** can engage the inner sidewall **81** of the proximal housing **79** of the trocar to retain the scraper **94** and sorbent element **86** therein at a location just distal of the duckbill seal **24**. In use, instruments passed through the working channel **4** of the trocar will be engaged by the scraper **94**, which scrapes fluid off of the outer surface of the instrument. The fluid is wicked away from the opening **52** in the scraper **94** by the channels **56**, which deliver the fluid to the sorbent element **86** surrounding the scraper **94**. Thus, similar to the embodiment of FIG. **1**A, when the instrument is withdrawn, for example, the fluid will be prevented from being deposited onto the seals, and in particular the instrument seal **14**, thereby preventing the fluid from being transferred from the instrument seal **14** back onto the instrument upon reinsertion.

A person skilled in the art will appreciate that the fluid remover assemblies **40**, **80** can have a variety of other configurations. FIGS. **3**A-**10**B illustrate additional exemplary embodiments of fluid removers, e.g., scrapers, sorbents, and wicking elements, or combinations thereof. In these embodiments, the fluid removers are all located distal of the channel seal, e.g., duckbill seal or other zero-closure seal, and distal of the instrument seal **14**. However a person skilled in the art will appreciate that the particular location of the fluid remover can vary and the fluid removers can be positioned anywhere within the trocar.

FIGS. **3**A-**3**C illustrate one embodiment of a fluid remover assembly **100** having a scraper and a sorbent. In particular, as best shown in FIG. **3**B, the fluid remover assembly **100** can include a stabilization cup **106** coupled to a flange **108**. The stabilization cup **106** can be formed from a sorbent material and the flange **108** can seat the cup **106** within the proximal housing **6** of the trocar **2**, as shown in FIG. **3**C. A scraper element in the form of a scraper disc **102** can be positioned between the flange **108** and the stabilization cup **106**, and a sorbent ring **104** can be coupled to a distal surface **103** of the scraper disc **102**. The scraper disc **102** can have a central opening **105** extending therethrough and configured for scraping fluid off of surgical instruments passed through the working channel **4** of the trocar **2**. As an instrument is passed through the working channel **4**, fluid can be scraped by the scraper disc **102** and sorbed by the sorbent ring, as well as by the stabilization cup. As can be seen in FIG. **3**B, the flange **108**, scraper disc **102**, and sorbent ring **104** can each optionally include cut-outs **110** to fit around the stop-cock **13** associated with the trocar **2**. In use, the fluid remover assembly **100** can be formed as a drop-in unit that fits within the proximal housing **6** of the trocar **2**. As shown in FIG. **3**C, the assembly **100** can be seated in a distal portion of the proximal housing **6** at a location just distal of the duckbill seal **24**. The fluid remover assembly **100** will thus remove fluid from instruments passed through the working channel **4** of the trocar, thereby preventing fluid from being deposited onto the seals, and in particular the instrument seal **14**, and/or redeposited onto instruments passed through the working channel **4**.

FIGS. **4**A-**4**C illustrate another embodiment of a fluid remover assembly **114** that is similar to the assembly shown in FIGS. **3**A-**3**C, however in this embodiment the assembly **114** does not include a stabilization cup. As shown, the fluid remover assembly includes a substantially planar circular scraper disc **116** having a central opening **115** for receiving a surgical instrument. The scraper disc **116** can be seated within a flange or retainer ring **118** configured to be positioned within the proximal housing of a trocar. A sorbent ring **120** can be positioned adjacent to a distal surface **117** of the scraper disc **116** and it can act to sorb any fluid that is scraped off of instruments passed through the scraper disc **116**. When disposed within a trocar, the flange **118** can act as a support structure to hold the scraper disc **116** and the sorbent ring **120** in a fixed position within the proximal housing. While the position can be distal to the duckbill seal, as indicated above the assembly can be located at various other portions within the trocar, including between the duckbill seal and the instrument seal, proximal to the instrument seal, or within any portion of the cannula.

In another embodiment, shown in FIGS. **5**A-**5**C, a fluid remover assembly **122** is provided and can have a generally conical configuration with a scraper **124** having a proximal generally planar flange **125** and a conical body **126** extending distally therefrom and defining a central opening **128**. The conical body **126** can have a plurality of slits **127** extending proximally from a distal end thereof and designed to reduce insertion and withdrawal forces on a surgical instrument passed therethrough. The conical body **126** can be surrounded by a conical sorbent element **130** such that the conical body **126** is nested within the conical sorbent element **130**. When assembled and disposed within a trocar, as shown in FIG. **5**C, the flange **125** can be seated within the proximal housing **6** just below the duckbill seal **24** and it can mate to or engage the inner sidewall of the housing **6** to retain the fluid remover assembly therein. In use, as an instrument is passed through the working channel, the scraper **124** can engage and scrap fluid off of the instrument and the sorbent element **130** can sorb the fluid. A person skilled in the art will appreciate that any number of geometries can be used in a similar way. Also, a size or diameter of a flange can be adjusted as needed, or the flange can be removed, to seat the fluid remover assembly at other locations within the trocar.

FIGS. **6**A-**6**C illustrate additional embodiments of conical scrapers **132***a*, **132***b*, **132***c* that are similar to the scraper **124** described above and shown in FIGS. **5**A-**5**C. As with the previous embodiment, the scrapers **132***a*, **132***b*, **132***c* in FIGS. **6**A-**6**C are positioned distal to the duckbill seal **24**. Such a configuration can prevent fluid on instruments being inserted and/or withdrawn from being deposited onto the duckbill seal, as well as the more-proximally located instrument seal **14**. In an exemplary embodiment, each scraper **132***a*, **132***b*, **132***c* can be made from a pliable material and can include at least one slit formed therein and configured to allow the scrapers **132***a*, **132***b*, **132***c* to radially expand. A variety of configurations are available for the slit(s). In the embodiment shown in FIG. **6**A, a single slit **134** extends diagonally around the scraper **132***a* such that the slit **134** follows the shape of the cone. In another embodiment shown in FIG. **6**B, multiple slits **137** extend proximally from the distal end of the cone and terminate at a location **139** just distal to the proximal end. Such a configuration can yield a scraper having multiple scraping segments **138**. As further shown in FIG. **6**B, each scraping segment **138** can also include a notch or cut-out **140** formed in an outer surface at the distal end thereof to allow the segment **138** to expand and contact as instruments are passed therethrough. FIG. **6**C illustrates another exemplary embodiment of a cone shaped scraper **132***c*. Similar to the scraper **132***b* shown in FIG. **6**B, the scraper **132***c* includes several slits **142** that extend proximally from the distal end thereof. In this embodiment, however, the slits **142** increase in width in a distal to proximal direction such that each scraping segment **143** has a distal end **144** with a width that is greater than a width of a proximal end **145** thereof. As indicated above, in use the slit(s) **134**, **137**, **142** formed in the scrapers **132***a*, **132***b*, **132***c* allow the scrapers to radially expand as a surgical instrument is passed therethrough, thus accommodating instruments of various sizes while still being effective to scrape fluid off of the instruments.

FIG. **7** illustrates another embodiment of a fluid remover positioned just distal of a channel seal, e.g., duckbill seal **150**, in a proximal housing of a trocar. In this embodiment, the fluid remover is in the form of sorbent flapper doors **152**. The flapper doors **152** can have various shapes and sizes, and they can be formed from any number of components. For example, the flapper doors **152** can be in the form of two sidewalls **153** that are movable relative to one another. The sidewalls **153** can have a profile that is similar to the profile of the duckbill seal **150**. In other embodiments, the flapper doors **152** can have a shape that corresponds to the shape of the duckbill seal **150**. A person skilled in the art will appreciate that various configurations are possible. The flapper doors **152** can be seated inside the proximal housing **6** and attached to the housing **6** by any attachment means known in the art, including by mechanical means, adhesives, etc. The flapper doors **152** can define an opening **154** therebetween for receiving a surgical instrument, and the opening **154** can be positioned just distal of the seal face **151**. In use, the flapper doors **152** can move from a closed or substantially closed position to an open position as an instrument is passed through the duckbill seal **150** and the flappers door **152**. The doors **152** can contact and engage the surgical instrument as it is being passed therethrough to sorb fluids off of the instrument. The flapper doors **152** can also sorb any excess fluid that is scraped off of the instrument by the duckbill seal **150** and that falls distally from the duckbill seal **150**.

In a similar embodiment, shown in FIG. **8**, the fluid remover can be in the form of a wicking element rather than a sorbent. In the illustrated embodiment, the wicking element is in the form of first and second wicking fingers **160***a*, **160***b* that are coupled to opposed outer edges **162** of the seal face **161** on the duckbill seal **163**. The wicking fingers **160***a*, **160***b* can be in the form of elongate members that follow the natural shape of the inner sidewall **165** of the proximal housing **6** of the trocar **2** so that fluid will run naturally down the fingers **160***a*, **160***b*. The wicking fingers **160***a*, **160***b* can also include a sorbent reservoir **164** disposed on a distal end thereof. In the illustrated embodiment, the sorbent reservoir **164** on each finger **160***a*, **160***b* is in the shape of ring seated within the proximal housing **6** and effective to sorb the fluids wicked away from the duckbill seal **163** by the wicking fingers **160***a*, **160***b*. The sorbent reservoir **164** can, however, have various other configurations such as ring segments. In use, as fluids are deposited on the duckbill seal **163** by instruments passing therethrough, the fluid will naturally flow to outer corners or edges of the seal face **161**. The surface difference between the wicking fingers **160***a*, **160***b* and the duckbill seal **24** will cause fluid to flow from the seal **163** to the fingers **160***a*, **160***b* and down the fingers **160***a*, **160***b* into the sorbent reservoir **164**. As will be appreciated by those skilled in the art, the wicking fingers **160***a*, **160***b* can be formed integrally with the duckbill seal **163** or can simply be in close contact with sealing face **161** of the duckbill seal **163**.

FIG. **9** illustrates another embodiment of a fluid remover that is positioned distal of a zero-closure seal. Similar to the embodiment shown in FIG. **7**, the fluid remover is in the form of a sorbent. However, in this embodiment the sorbent is a sorbent grommet **172**. The grommet **172** can have a generally circular or conical configuration with an opening **173** formed therethrough, as shown, but it can have any number of other geometries to facilitate passage of an instrument therethrough. The grommet **172** can also include multiple slits **174** formed therein and extending radially outward from the opening **173** to reduce insertion and withdrawal forces on an instrument being passed therethrough. In use, the grommet **172** can be seated within a distal portion of the proximal housing **6** of the trocar, just distal of the duckbill seal **166**, and the opening **173** can be positioned coaxial with the working channel **4**. As a surgical instrument is passed therethrough, the grommet **172** will contact the instrument and sorb any fluid on the instrument. The grommet **172** can also sorb any fluid that drips off of the duckbill seal **166** as the seal **166** scrapes the instrument.

In other embodiments, the zero-closure seal itself can be modified to include a fluid remover. For example, FIGS. **10**A and **10**B illustrate another embodiment of a duckbill seal **176** in which the seal face **168** is extended distally and expanded in width to cause the outer ends of the seal face **168** to contact the inner sidewall **169** of the proximal housing **6** of the trocar, thereby forming a wicking element. In use, when an instrument is passed through the duckbill seal **176**, the seal face **168** will scrape fluid off of the instrument. The fluid will naturally run outward toward the outer-most edges of the seal face **168**. Since the outer edges are in contact with the inner sidewall **169** of the proximal housing **6**, the fluid will be wicked away from the seal face **168** and onto the inner sidewall **169** of the housing **6**. While not shown, the housing **6** can optionally include a sorbent disposed therein for sorbing the fluid wicked away from the seal.

FIG. **11** illustrates another embodiment of a modified zero-closure seal **186**. In this embodiment, a sorbent element **180** is nested inside of the duckbill seal **177**, and a second duckbill seal **178** is nested within the sorbent element **180**. The nested sorbent **180** and the nested duckbill seal **178** can have two sealing walls, **182**, **184** similar to the duckbill seal **177**, that meet at a seal face that is configured to form a seal when no instrument is disposed therein and that are configured to open when a surgical instrument is passed therethrough. The body of the nested sorbent **180** and the nested duckbill **178** can each have a profile similar or identical to the duckbill seal **177**, except smaller in size to all fit for a nested configuration. The components **177**, **178**, **180** can merely be seated within one another, or they can be attached to one another using various attachment mechanisms known in the art, including a press fit, glue, etc. In use, the seal face of all three components will contact a surgical instrument as it is passed through the seal assembly. The sorbent **180** will thus sorb any fluid on the instrument, as well as fluid scraped off of the instrument by the duckbill seal **177** and the nested duckbill seal **178**.

FIGS. **12**A-**12**B illustrate another embodiment of a modified zero-closure seal **190**. In this embodiment, the duckbill seal **191** includes two sorbent bars **192** disposed therein and extending thereacross. The sorbent bars **192** can be positioned to extend substantially parallel to the seal face **193**, or to extend substantially perpendicular as shown. The seal **190** can also include a sorbent ring **194** positioned around an inner sidewall **193** of the duckbill seal **191** and in contact with the sorbent bars **192**. The sorbent ring **194** can provide a reservoir for fluid collected by the sorbent bars **192**. In use, the sorbent bars **192** will contact and engage a surgical instrument as it is passed through the duckbill seal **191**, and will thus sorb fluid away from the surgical instrument.

As indicated above, the various fluid remover embodiments disclosed herein can be located anywhere within a trocar or other access device, including distal of a channel seal, between a channel seal and an instrument seal, or proximal of an instrument seal. The position of the fluid remover can also vary relative to an insufflation port, as will be discussed in more detail below. The fluid removers can also be formed integrally with the seal(s) and/or portions of the housing, and any combination of fluid removers can be used. FIGS. **13**-**22**B illustrate various exemplary embodiments of fluid removers that are formed integrally or incorporated into an instrument seal, or located adjacent to an instrument seal and thus proximal to a channel seal.

Turning first to FIG. **13**, in this embodiment the fluid remover **200** is in the form of a combination scraper and sorbent. In particular, the fluid remover **200** includes a generally planar circular scraper disc **202** having an opening **204** formed therethrough and configuration to be positioned coaxial with the working channel **4** in the trocar **2**. The opening **204** can be sized and configured to form a seal around an instrument passed therethrough. The fluid remover **200** can also include a sorbent disk **206** disposed concentrically around the opening **204** in the scraper **202**. In use, the scraper **202** will scrape fluid off of instruments passed therethrough, and the sorbent disk **206** will sorb the scraped fluid. The fluid remover **200** can be disposed within the proximal housing **6** of the trocar **2** using various techniques, but as shown in FIG. **13** the fluid remover **200** is configured to be engaged between the removable cap **5** and the distal portion of the proximal housing **6** of the trocar **2**. As a result, the scraper **202** and sorbent **206** will be positioned in alignment with the working channel **4** extending through the housing **6**, and will also be positioned between the proximal instrument seal and the distal channel seal.

FIG. **14** illustrates another embodiment of a fluid remover **210** having a combination scraper and sorbent, however in this embodiment the fluid remover **210** is fully disposed within the removable cap **5** containing the instrument seal. As shown, a scraper **212** can be cone shaped and can be positioned just distal of the instrument seal. In other embodiments the scraper **212** can be planar. The scraper **212** can also replace or function as the instrument seal. A sorbent ring **214** can be positioned concentrically around and in contact with an opening **216** in the distal end of the of the conical scraper **212**. As a result, the sorbent ring **214** will sorb any fluid scraped away from a surgical instrument extending through the scraper **212**.

In yet another embodiment, shown in FIGS. **15**A and **15**B, the fluid remover can be in the form of a scraper that is part of the instrument seal **218**. As shown, the instrument seal **218** is a multi-layer seal having the protector disposed on a proximal surface thereof, as previously described with respect to FIG. **1**E. The scraper can be in the form of a second protector **222** that is disposed distal to the multi-layer seal segments. The second protector **222** can have the same configuration as the protector of FIG. **1**E, however the second protector **222** can define an opening **224** that is configured to contact and engage a surgical instrument passed through the seal **218**. Accordingly, in use, the second protector **222** can engage and scrape fluid away from instruments passed through the seal **218**.

In another embodiment, shown in FIG. **16**, the fluid remover can be in the form of a multi-layer sorbent that is positioned between the multiple layers **20** of the seal **16**, as shown, or that is positioned between the multiple layers **22** of the seal protector **18**. The sorbent can be in the form of multiple sorbent sheets **232** that are layered in between the layers of the seal **16** (or seal protector **18**). Thus, in use, when an instrument is passed through the instrument seal, the sheets **232** will sorb any fluids scraped off of the instrument by the seal **14**, thereby preventing fluid from accumulating around the opening of the seal **14** and being reapplied to a surgical instrument as it is reinserted therethrough. The sorbent sheets **232** can be effective to sorb fluid, as well as to interrupt surface tension and/or capillary action between the seal and the protector. Thus, there should be no fluid in or near the seal opening and/or protector opening that will be able to touch or collect on an instrument being passed therethrough.

FIG. **17** illustrates another embodiment of a sorbent fluid remover. In this embodiment, the sorbent is in the form of a grommet **242** having a configuration similar to the grommet **172** previously described with respect to FIG. **9**. However, in this embodiment the grommet **242** is positioned adjacent to a distal surface **244** of the instrument seal **14**, rather than the zero-closure seal **24**. In particular, as shown in FIG. **17**, the grommet **242** can be disposed concentrically around a distal opening **246** formed in the removable cap **5** such that instruments passed through the instrument seal **14** will contact the grommet **242**, which will sorb fluids off of the instrument. The grommet **242** can also sorb any fluid that is scraped from or drips from the instrument seal **14**.

In another embodiment shown in FIGS. **18**A and **18**B, a wicking element is formed integrally with the multi-layer seal protector **18** previously described with respect to FIG. **1**E. As previously explained, the multi-layer seal **16** can have a natural shape that is slightly conical and it can include an opening sized to receive an instrument therethrough. The protector **18** likewise has an opening, however in the embodiment shown in FIGS. **18**A and **18**B the length of a protector **240** is decreased to thereby increase the diameter of the opening defined by the protector **18**. As a result, the protector **240** will have an opening that is larger than the opening in the seal **16** to create a flattened profile against the conical shape of the seal **16**, thereby creating a gap between the protector **240** and seal **16**. As surgical instruments are removed from the trocar, the gap will prevent fluids from collecting between the layers **20** of the seal **16** and will allow the protector **240** to wick fluids away from the opening of the seal **16**. Thus, if fluid is deposited on the seal **16**, there will be no capillary action to hold the fluid between the seal **16** and the protector **240**, thereby allowing the fluids to drain. In addition, when an instrument is passed through the protector **240** and seal **16**, the gap created between the seal **16** and protector **18** will prevent fluid from being squeezed from between the seal **16** and protector **240** and onto an instrument.

In another embodiment shown in FIGS. **19**A and **19**B, the multi-layer seal protector **248** has a wicking element in the form of camming ribs **250** disposed on a surface of each individual protector layer **249** so that the ribs **250** create pockets between the layers for wicking away and retaining fluid scraped off of instruments by the instrument seal. In the illustrated embodiment, the ribs **250** are offset by 90 degrees, although other geometries are possible as will be appreciated by those skilled in the art. In one embodiment, the ribs **250** can be disposed on a top or proximal surface of the protector. Thus, as a surgical instrument is passed through the instrument seal **14**, the instrument will contact the ribs **250** to thereby cam open the protector **248** and the seal, preventing the surgical instrument from coming into contact with the surface of the protector **248** and/or the seal. In another embodiment, the ribs **250** can be disposed on a bottom or distal surface of the protector, thereby creating a gap between the protector **248** and the seal to prevent capillary action and the trapping of fluid between the seal and protector **248**.

FIGS. **20**A and **20**B illustrate another embodiment of an instrument seal **254** having ribs for wicking fluid away from an opening in the seal **254**. In this embodiment, the instrument seal **254** is in the form of a deep cone seal having a flange **260** with a conical sidewall **262** extending distally therefrom. A distal portion **264** of the conical sidewall **262** tapers inward to define an opening **258** in the distal end **264** of the seal **254**. In the embodiment shown in FIG. **20**A, the sidewall **262** can include one or more ribs **266** formed on an external surface **261** thereof and extending between proximal and distal ends of the sidewall **262**, terminating at the opening **258**. The external ribs **266** can be effective to wick fluid away from the opening **258** in the seal **254**. In the embodiment shown in FIG. **20**B, the ribs **266** are formed on the inner surface **268** of the sidewall **262** and extend between proximal and distal ends of the sidewall **262**, terminating at the opening **258**. The ribs **266** will thus have a camming effect, causing any instrument inserted through the seal **254** to contact the ribs **266** to cam open the seal **254**, rather than contacting an inner surface **268** of the seal **254**.

In another embodiment, shown in FIG. **21**, the multi-layer seal protector **269** can include a plurality of holes **270** formed in the individual layers **271** of the protector **269** to form a wicking element for wicking fluid away from the seal. As fluid is trapped between the protector **269** and the seal when an instrument is passed through the instrument seal, the holes **270** act to wick away fluid from the seal and from the opening in the seal. The fluid can be retained within the holes **270** by surface tension so that an instrument passed through the seal will not contact the fluid retained in the holes **270**.

Various other modifications can also be made to the multi-layer seal protector previously described in FIG. **1**E to remove fluid from the seal or from instruments passed through the seal. In another embodiment, shown in FIGS. **22**A and **22**B, the protector segments **272** can include surface features, such as a roughened surface **276**, formed on the distal surface thereof. As shown in FIG. **22**B, when the protector segments **272** are positioned against the seal segments **20**, the roughened surface **276** will create a gap that separates the protector **273** from the seal, thus providing a path for fluid to wick away from the opening in the seal and from between the protector **273** and the seal.

FIGS. **23**A-**23**B illustrate another embodiment of a seal **280** that is configured to remove fluid. In this embodiment, the seal **280** has an hourglass configuration such that the seal **280** is a combination trocar and instrument seal. In other words, the seal **280** is effective to both form a seal within the working channel of the trocar when no instrument is disposed therethrough and to form a seal around an instrument disposed therethrough. The hourglass shape of the seal **280** allows a central portion **282** of the seal **280**, which in a natural state is in a closed configuration as shown in FIG. **23**A, to open and engage an instrument passed therethrough, as shown in FIG. **23**B, and thereby scrape any fluid off of the instrument. Due to the curvature in inner sidewalls **284** of the seal **280**, the removed fluid will flow away from the central portion thus preventing the fluid from being redeposited onto an instrument reinserted therethrough. The hourglass configuration of the seal **280** is also advantageous in that it will accommodate instruments of various sizes. The central portion **282** can also move or float relative to the central axis of the working channel in the trocar, thus accommodating off-axis instruments.

FIGS. **24**A-**29** illustrate various other exemplary embodiments of fluid removers. While certain embodiments are described as being disposed or formed in the cannula, a person skilled in the art will appreciate that, as with previous embodiments, the embodiments of FIGS. **24**A-**29** can likewise be disposed at various locations within a trocar and that various combinations of fluid removers can be used.

In the embodiment shown in FIGS. **24**A and **24**B, the fluid remover is in the form of a plurality of scraper elements that extend at least partially across the working channel **4** of the cannula **8**. The scraper elements can be relatively thin and can take the shape and form of wipers **292**, as best shown in FIG. **24**B, that will scrape or squeegee fluid off of a surgical instrument passed through the cannula **8**. The wipers **292** can be fixedly or hingedly coupled to an inner sidewall **294** of the cannula **8**, and they can be flexible to accommodate instruments of various sizes, and to allow both insertion and withdrawal of the instruments. The cannula **8** can also include any number of wipers **292**, and the wipers **292** can be spaced apart from one another, or they can be in a stacked configuration. The wipers **292** can have a conical configuration such that each wiper **292** extends around the entire inner diameter of the cannula **8**. Alternatively, the wipers **292** can be formed into individual segments that are positioned a distance apart from one another, e.g., approximately 90 degrees apart within the interior surface **294** of the cannula **8**. The segments can be layered within the cannula **8** so that different parts of the surgical instrument come into contact with the wipers **292** at different heights as the instrument is being passed therethrough. The wipers **292** can also be in contact with a sorbent element **296**, or include a sorbent portion, such that the collected fluid drips onto or is wicked into the sorbent material and away from possible contact with a reinserted instrument. As shown in FIGS. **24**A-**24**B, the sorbent element **296** is located adjacent to the inner sidewall **294**, and thus radially outward from the wiper body **292**. The sorbent elements **296** can be formed into a wall of the cannula **8**, so that the cannula **8** is partially formed from the sorbent elements **296**. The sorbent elements **296** can also be formed within grooves in the cannula wall and/or can be adhered directly to the cannula wall by any attachment mechanism known in the art, for example an attachment ring **297**. In use, as an instrument is passed through the cannula **8**, the instrument will be scraped on all sides simultaneously by the plurality of wipers **292**. The fluid will flow outward where it will be sorbed by the sorbent element **296**.

FIG. **25** illustrates another exemplary embodiment of a scraper **300**. In this embodiment, the scraper **300** is substantially cone shaped increasing in diameter in a distal direction. A proximal end **302** of the scraper **300** includes an opening **304** formed therethrough, and a fluid collection member is formed at a distal end **306** thereof and extends inwardly. The fluid collection member can have a variety of configurations and can be generally configured to collect fluid scraped by the scraper **300**. In one exemplary embodiment, as shown, the fluid collection member can be in the form of a substantially C-shaped lip **308** extending inwardly from the distal end **306** of the scraper **300**. At least a portion of the fluid collection member can also optionally be sorbent thereby enabling the fluid collection member to both collect and sorb fluid scraped by the scraper. The scraper **300** can be formed from a pliable material such that it can radially expand to engage a surgical instrument extending therethrough. In use, the narrow proximal end of the scraper **300** can engage a surgical instrument passed therethrough to thereby scrape fluid away from the instrument. The fluid scraped away from the instrument will run down an inner surface **310** of the scraper **300** and be collected and/or sorbed by the fluid collection member disposed at the distal end **306** of the scraper **300**. While the scraper **300** is generally indicated as being disposed in the cannula **8**, the scraper **300** can likewise be disposed anywhere within the trocar **2**, including in the proximal housing **6**.

FIG. **26** illustrates another exemplary embodiment of a scraper **312**. In this embodiment, the scraper **312** includes first and second rotatable members **314***a*, **314***b* that are configured to rotate and engage a surgical instrument as the instrument is passed therethrough. The first and second rotatable members **314***a*, **314***b* can have a variety of shapes and sizes. In the illustrated embodiment, the first and second rotatable members **314***a*, **314***b* are spool shaped. The spools can be configured such that the geometry of second member **314***b* complements that of the first member **314***a*. As shown, the first member **314***a* includes a substantially spherically shaped central portion **316** that corresponds with a concave cut-out **318** in the second member **314***b*. The geometry of the spools can have several shapes including, but not limited to, straight sided cylindrical, c-shaped, and indented cylindrical. The first and second rotatable members **314***a*, **314***b* can be positioned at a variety of locations in the cannula, or within the proximal housing of a trocar, and they can be formed from a variety of materials including, but not limited to, rigid, pliable, and sorbent materials. In use, the rotatable members **314***a*, **314***b* can rotate and engage a surgical instrument passed therethrough to thereby scrape and optionally sorb fluid away from the instrument.

FIGS. **27**A-**27**C illustrate another embodiment of a fluid remover in the form of a removable tip or sleeve **322** that can be removable coupled to a distal end **324** of the cannula **8**. As shown, the sleeve **322** is in the form of a generally cylindrical housing with a tapered distal end **326**, similar to the distal end **324** of the cannula **8**. A proximal end **328** of the sleeve **322** can be sized to fit over and engage the distal end of the cannula **8**, e.g., by interference fit, and the distal end of the housing can include an opening **330** formed therein and sized to receive a surgical instrument therethrough. The sleeve **322**, or at least a portion of the sleeve **322** surrounding the opening **330** at the distal end **326**, can be formed from a compliant or expandable material to allow the opening in the sleeve **322** to radially expand as an instrument is passed therethrough. Exemplary compliant materials include, but are not limited to, polyisoprene, pellathane, and silicone. In use, as a surgical instrument is passed through the opening **330** in the sleeve **322**, the opening **330** will scrape fluid off of the instrument, thereby preventing the fluid from being dragged into the trocar and deposited on the seals.

In another embodiment shown in FIG. **28**, an hourglass shaped seal **340**, similar to the seal **280** described with respect to FIGS. **23**A-**23**B is provided, however the seal **340** includes a wicking element in the form of one or more cut-outs or slots **342** formed in the central, reduced-diameter portion **344**. Similar to the seal **280** previously described with respect to FIGS. **23**A and **23**B, the hourglass shape will allow the central portion **344** to scrape or squeegee fluid from a surgical instrument passed therethrough. The cut-outs or slots **342** will allow the scraped fluid to be wicked through the slots **342** to an exterior surface **346** of the seal **340**.

In another embodiment shown in FIG. **29**, the wicking element can take the form of a plurality of slots **350** formed in the working channel **4** of a cannula **352**. The slots **350** can have any size and shape sufficient to transfer fluid disposed on an inner surface of the cannula **352** to an outside surface **354** of the cannula **352**. Thus, as an instrument is passed through the cannula **352**, any fluid that drips down the inner surface of the cannula **352** will be transferred to the external surface **354** of the cannula **352** through the slots **350**.

FIGS. **30**A-**30**J illustrate another embodiment of a trocar **400** having a fluid remover **430** disposed therein. As shown, the trocar **400** has a proximal housing **402** and a distal cannula **404** with a working channel **408** formed through and extending between proximal and distal ends **400***a*, **400***b* thereof. The housing **402** can include one or more seals that are effective to seal the working channel **408**, i.e., to prevent the escape of insufflation, when no instrument is disposed therethrough and/or when an instrument is disposed therethrough. As shown in FIGS. **30**B and **30**C, the housing **402** includes a proximal instrument seal, in the form of a multi-layer seal **412**, that is effective to form a seal around an instrument inserted therethrough, and a distal channel seal, such as a duckbill seal **410**, that is effective to seal the working channel when no instrument is inserted therethrough. One exemplary embodiment of a duckbill seal **410** that can be used with the present invention is disclosed in U.S. patent application Ser. No. 11/771,263 filed on Jun. 29, 2007 and entitled "Duckbill Seal With Fluid Drainage Feature," by Paul T. Franer and Thomas A. Gilker. Such a duckbill is particularly useful as it has a low profile and has fluid drainage features that can assist in further preventing fluid from being redeposited onto instruments inserted through the seals. A person skilled in the art will appreciate that any number, type, and configuration of channel and/or instrument seals can be positioned within the housing **402** at various locations. The housing can also include an insufflation port **406** is formed in the housing **402** for providing an insufflation gas to the working channel **408**.

As indicated above, the housing **402** can include a fluid remover **430** positioned therein and configured to remove fluid from a surgical instrument inserted therethrough. The fluid remover **430** can have an opening **470** formed through a center portion thereof, in axial alignment with the working channel **408**, for receiving a surgical instrument. The opening **470** can be effective to remove fluid from a surgical instrument upon insertion and/or withdrawal therethrough. In an exemplary embodiment, the fluid remover **430** is preferably positioned distal to the seals **412**, **410** so that fluid collected on the instrument when disposed in a body cavity can be removed from the surgical instrument before it is withdrawn through the seals **412**, **410**, thus preventing the fluid from being deposited on the seals and thereafter deposited onto an instrument inserted into the trocar. In order to position the fluid remover **430** distal to the seals **412**, **410**, the fluid remover **430** will positioned proximal to, distal to, or in the path of the insufflation port. Where the fluid remover **430** is positioned in the path of or distal to the insufflation port, it is preferably configured so that it does not block the path of an insufflation gas from the port through the distal cannula **404**. During many surgical procedures using a trocar, insufflation is used to expand the body cavity into which the trocar extends. Trocars can thus have an insufflation port, such as the port **406** shown in FIGS. **30**A-**30**C, that is positioned distal to the seals **412**, **410** so that the seals are effective to prevent gas from flowing out of the proximal housing **402**. In this way, a constant flow of gas is maintained through the distal cannula **404** and into the body cavity. Since the port **406** is positioned distal to the seals **412**, **410**, in an exemplary embodiment, in order to maintain a low profile housing and position the fluid remover **430** distal of the seals, the fluid remover **430** can be positioned adjacent to or distal to the port **406**. As such, the fluid remover **430** is preferably configured to allow air to pass therethrough and/or therearound such that it does not block the flow of insufflation gas from the port **406** to the cannula **404** when an instrument is inserted through the opening **470** in the fluid remover **430**. In other words, the fluid remover **430** can have a configuration that allows the passage of insufflation gas from the port **406** to the distal cannula **404** even when an instrument is disposed through the fluid remover **430**. FIGS. **30**A-**30**J illustrate one such embodiment of the fluid remover **430** that is in the pathway of the flow of gas from the port **406** to the cannula **404**. In this embodiment, a cut-out or pathway is provided in a portion of the fluid remover **430** to allow the passage of gas therethrough from the port **406** to the cannula **404**, as will be discussed in more detail below. The fluid remover **430** can also include other features to facilitate the passage of gas therethrough, as will be discussed in more detail below.

The fluid remover **430** can have various configurations and it can include any one or more of a wicking element, a sorbent, and a scraper. FIGS. **30**C-**30**F illustrate one embodiment of the fluid remover **430** that is positioned distal to the seals **412**, **410** and in proximity to the insufflation port **406**. The fluid remover **430** generally includes a sorbent **414** disposed within the housing and disposed around a crown **420**, a scraper **422** positioned on a proximal surface of the crown **420**, and a lid **418** positioned against a proximal surface of the scraper **422**.

As shown in more detail in FIGS. **30**F and **30**G, the scraper **422** of the fluid remover **430** can have many shapes and configurations, but in the illustrated embodiment the scraper **422** is disc shaped and has an opening **424** formed through a center portion thereof. The scraper **422** can be configured to remove fluid from a surgical instrument passing through the opening **424** by contacting the surgical instrument and scraping and/or squeegeeing its circumference. In an exemplary embodiment, the scraper **422** is formed from a flexible and resilient material to allow the opening **424** of the scraper **422** to expand around and engage an outer wall of an instrument passed therethrough.

The scraper **422** can also include features to direct fluid flow. For example, as shown in FIG. **30**G, the scraper can include one or more channels **422***c* formed in a distal surface thereof and extending radially outward from the opening **424** such that fluid scraped off of an instrument being withdrawn through the opening **424** will flow through the channels and radially away from the opening **424**. As further shown in FIGS. **30**F and **30**G, the scraper **422** can also include one or more holes **422***h* formed therethrough for receiving pins formed on the crown **420**, as will be discussed in more detail below. The holes **422***h* allow the scraper **422** to rest on a proximal surface of the crown **420** and to be captured between the crown **420** and the lid **418**. The holes **422***h* can also have a size that allows air to pass therethrough when the pins of the crown **420** are disposed therein. Such a configuration can assist in preventing the fluid remover **430** from functioning as a seal, as will be discussed in more detail below. In some embodiments, however, the scraper **422** can also be formed as an instrument seal and/or as a scraper for smaller diameter surgical instruments and a seal for larger diameter surgical instruments.

In certain exemplary embodiments, in order for the scraper **422** to effectively wick fluid radially outward from the opening and toward the sorbent, all or portions of the scraper can be formed from or can include a hydrophilic material. For example, the scraper can be formed from a hydrophilic material, such as a nylon, and/or the scraper can be spray coated, dip-coated, plasma etched, or otherwise coated using various known coating techniques, with a surfactant coating that renders the scraper or portions thereof hydrophilic. In an exemplary embodiment, where the scraper is formed from a hydrophobic material, such as a polyisoprene, a hydrophilic coating is applied to the scraper to render the scraper hydrophilic. The coating can be applied to any one or more of the surfaces of the scraper, and it can be applied at any stage during manufacturing. In one embodiment, the scraper can be soaked in a surfactant bath during manufacturing to render the entire scraper hydrophilic. Exemplary coating materials include, by way of non-limiting example, Dodecylbenzene sodium sulfonate (SDBS), and Sodium Dodecyl Sulfate (SDS). The coating is preferably one that remains stable during sterilization, such as gamma and thermal sterilization.

A person skilled in the art will appreciate that various factors can be altered to facilitate the wicking action of the scraper. For example, the contact angle of a drop of fluid on a hydrophilic surface of the scraper can be optimized so that fluid will spread upon contact with the surface. In certain exemplary embodiments, the hydrophilic material can have a low contact angle, such as 90 degrees or less. Other factors that can affect the ability of the scraper to wick fluid away from the opening include the smoothness of the surface, the geometry of the wicking channels, and the surface tension of the fluid being applied. For example, the channel geometry can be designed so as to provide the capillary forces necessary to drive fluid to a minimum capillary height so that the fluid will extend just past the outer wall of the crown **420** to reach the sorbent **414**. The channel geometry can be altered to achieve the desired capillary height. FIG. **30**H illustrates one exemplary embodiment of a channel geometry that is optimized to facilitate the capillary action of the channel. As shown, the channel has a generally U-shaped cross-sectional shape, with the inner corners, located at the base of the channel, being rounded and having a radius of curvature r_1, and the outer corners, located at the opening of the channel, being rounded and have a radius of curvature r_2. The channel can also have a width w at the base, as measured between the opposed sidewalls of the channel, that differs from a width w1 at the opening, as measured between the outer rounded corners, and that also differs from a maximum width w_2 as measured from the outer-most ends of the channel at the opening. The difference between width w and width w_1 is indicated by reference x. The channel can further have a maximum height h, as measured from the base to the outer-most ends of the channel at the opening, that differs from a height h_1, as measured from the base to the outer rounded corners. The particular dimensions of the channel can vary. For example, the radius of curvature r_1 at the base of the channel can be less than the radius of curvature r_2 at the opening of the channel, and the width w at the base of the channel is less than the width w1 at the opening, which in turn is less than the maximum width w_2 such that the width of the channel gradually increases from the base to the opening. In an exemplary embodiment, however, the width w at the base of the channel is preferably equal to or greater than the width w1 at the opening. The dimensions and cross-sectional shape of the channel can also vary along the entire length of the channel. For example, the channel can have a height and/or width that increases or decrease radially outward, such that the height and/or width of the channel near the central opening in the scraper is either less than or greater than the height and width of the channel near the outer perimeter of the scraper. Each channel can also reach a maximum height and/or width at a certain distance from the central opening, and the height and/or width can then remain constant along the remainder of the channel extending radially outward from that location. A person skilled in the art will appreciate that the channel can be modified to obtain a desired capillary height so as to cause fluid to be driven from the scraper opening, past the crown, and to the sorbent.

As indicated above, other modifications can be made to achieve an optimum wicking effect. In another embodiment, the scraper and sorbent can both be configured to have a surface energy gradient, such that the surface energy increases as fluid travels from the opening in the scraper, along the channels, and into the sorbent.

The fluid remover **430** can also include a scraper crown **420**, shown most clearly in FIG. **30**F, that can extend distally from a distal surface of the scraper **422** and that can assist in mounting the scraper **422** and sorbent **414** within the housing. The scraper crown **420** can have various configurations, but in the illustrated embodiment it has a ring shaped body **434** with multiple pins **436** extending proximally therefrom. The pins **436** can extend through the corresponding holes **422*h*** formed in the scraper **422** and into holes **418*h*** formed in the lid **418**, as shown in FIG. **30**J. The crown **420** and lid **418** can be mated to one another using various techniques, such as a pressed fit or interference fit, adhesive or welding, etc. By engaging the scraper **422** between the lid **418** and the crown **420**, the scraper **422** can have an outer diameter that is less than an inner diameter of the housing **402** such that a gap G is provided between the scraper **422** and the housing **402**, as shown in FIG. **30**D. The gap G will allow air to flow proximally past the scraper **422**.

As further shown in FIG. **30**F, the scraper crown **420** can also include a cut-out **426** formed in a sidewall thereof. One or more flange members **440** can extend radially outward from a sidewall of the scraper crown **420** on each side of the cut-out **426** formed through the crown **420** to define a pathway. The flange members **440** can be positioned to axially align with the a cut-out formed in the sorbent **414** and a cut-out formed in the lid **418**, as will be discussed in more detail below, to form a complete pathway that allows the flow of insufflation gas from the insufflation port **406**, through the cut-outs, and to the working channel **408** into the distal cannula **404**. This allows insufflation to be delivered through the cannula while an instrument is passed through the fluid remover **430** and occludes the working channel. The flange portions **440** can be positioned on either side of an opening of the insufflation port **406**, through which the insufflation gas flows. As a result, a pressure on each side of the fluid remover will be equalized.

The shaped scraper lid **418** is shown in more detail in FIGS. **30**I and **30**J, and it can have a generally circular or ring-shaped configuration that rests proximal to the scraper. In use, the lid **418** can serve to protect the proximal surface **432** of the scraper **422** from the insertion of sharp surgical instruments by acting as a guide or funnel for the surgical instrument into the opening **424** of the scraper **422**. As indicated above, the scraper lid **418** can include one or more holes **418*h*** formed in a distal surface thereof for receiving the pins **436** formed on the crown **420**. The scraper lid **418** can also include an opening **418*o*** through which a surgical instrument can extend that is in axial alignment with the opening **424** formed in the scraper **422**, and a cut-out **448** formed in a sidewall or perimeter of the scraper lid **418** that aligns with the cut-out **446** formed in the scraper crown **420** and the sorbent **414**.

As shown in FIG. **30**J, in one embodiment the scraper lid **418** can further include a circular bead or compression ridge **450** protruding distally beyond a distal-most surface thereof such that the ridge extends toward and presses against the proximal surface of the scraper **422** to hold the scraper **422** in controlled compression between the compression ridge **450** on the lid **20** and the proximal surface of the crown **420**. The compression ridge **450** can also function to seal off and prevent fluid from flowing back toward the opening of the scraper **422**.

While there can be many configurations for the fluid remover **430**, in the embodiment shown in FIGS. **30**B-**30**E, the fluid remover **430** also includes a sorbent **414** positioned circumferentially around the scraper crown **420** and configured to sorb fluid scraped by the scraper **422**. As shown in FIG. **30**F, the sorbent **414** can be configured to be positioned around the scraper crown **420**, and thus can have a cut-out **444** formed therein that aligns with the cut-out **426** formed in the crown **420**. The terminal ends of the sorbent **414** will thus abut the flange **440** on the crown **420**. As a result, the sorbent **414** will be substantially C-shape. The cut-out **444** in the sorbent **414** will also allow air to flow all the way around the outside of the scraper **422**, due to the gap G between the outer perimeter of the scraper **422** and the housing. The cut-out in the sorbent **414** will thus continue to allow air to pass by and around the scraper **422** in the event the sorbent **414** becomes clogged. This is particularly advantageous, as air forced to flow through the sorbent **414** could potentially push fluid out of the sorbent **414**. The sorbent **414** can be secured around the scraper crown **420** using any method known in the art including, for example, an adhesive or simply by an interference fit between an interior wall of the housing **402** and the scraper crown **420**. As will be appreciated by those skilled in the art, the sorbent **414** can have a solid ring shape, or any other shape, and it can be composed of multiple individual portions as needed.

While the sorbent **414** preferably has a shape that corresponds to the shape of the crown **420**, the sorbent **414** can be configured to be compressed between the crown **420**, the scraper **422**, and the housing **402**. Thus, the sorbent **414** can have an initial cross-sectional shape that is more square and it can deform into a shape that is more triangular. The sorbent **414** can be formed from various materials that allow it to be compressed, while still allowing the sorbent **414** to sorb fluid. The sorbent **414** can also be permeable such that air can flow therethrough.

The particular size of the sorbent **414** can also vary, but in an exemplary embodiment the sorbent **414** has an inner diameter that is greater than a diameter of the opening **424** in the scraper, such that the sorbent **414** will only contact the scraper **422** at a location radially outward of the opening **424**. This will allow fluid to flow from the opening, through the channels **422***c*, and then sorbed by the sorbent. In an exemplary embodiment, the sorbent is positioned radially outward of the holes **422***h* formed in the scraper, as this allows the sorbent **414** to be positioned around the crown **420**.

As indicated above, when the fluid remover **430** is fully assembled, it can rest within a distal portion of the proximal housing **402**. The sorbent **414** can be positioned in contact with an inner surface of the housing **402**, the crown **420** can be disposed within the sorbent **414**, the scraper **422** can rest on the crown **420** and be positioned in contact with the sorbent, and the lid can be positioned on the scraper **422** and be mated to the crown **420**. The lid **418** can optionally be sonic welded or otherwise fixedly mated to the housing **402** to secure the fluid remover **430** therein. As shown in FIG. **30**F, the sorbent **414** can include surface features, such as longitudinally extending grooves **415** formed on an inner surface thereof and configured to align with and receive the pins **436** on the scraper crown **420**.

When disposed within the housing **402**, the fluid remover **430** will be positioned in the path of insufflation. In particular, referring again to FIGS. **30**C and **30**D, the insufflation port **406** has a lumen **460** extending therethrough. The lumen **460** defines a longitudinal axis LA and has a cylindrical interior surface with a proximal-most interior surface **462** and a distal-most interior surface **464**. The fluid remover **430** is generally positioned in the pathway of the lumen **460** and more particularly, it is positioned such that the proximal-most interior surface **462** of the lumen **460** is positioned distal to the scraper **422** and the longitudinal axis LA extends through a mid-portion of the sorbent **414**. In other words, the sorbent **414** is positioned in the path of the flow of gas from the insufflation port **406** to the distal cannula. A person skilled in the art will appreciate that the various components of the fluid remover **430** can be positioned at various locations relative to the insufflation port **406**. Since portions of the fluid remover **430** in the illustrated embodiment are positioned in the pathway of air flow from the insufflation port **406** to the distal cannula, the cut-outs **426** and **444** in the crown **420** and sorbent **414** will allow airflow to pass therethrough and into the distal cannula.

In use, a surgical instrument can be inserted through the seals **412**, **410** and through the opening **470** in the fluid remover **430** as needed in a particular procedure. Using the insufflation port **406**, insufflation gas can be introduced into the working channel **408** of the trocar **400** such that insufflation is achieved distal to the seals **412**, **410** and to the fluid remover **430**. The insufflation gas can travel along the pathway defined by the flange portions **440**, through the cut-outs **426**, **444** in the crown **420** and sorbent **414**, respectively, and into the working channel **408** of the distal cannula **404**. In this way, the fluid remover **430** can be distal to the seals **412**, **410** to remove fluid from instruments being withdrawn while allowing the flow of insufflation gas into the distal cannula. As a surgical instrument is withdrawn from the working channel **408**, fluid scraped from the surgical instrument by the scraper **422** flows radially outward and is sorbed by the sorbent **414**, thus keeping the fluid away from any instrument that may be reinserted into the working channel **408**. The fluid remover **430** thus allows for the removal of fluid from a surgical instrument at a position distal to the seals **412**, **410** while also allowing the introduction of insufflation gas distal to both the seals **412**, **410**. A person skilled in the art will appreciate the variations possible for the positioning of seals and fluid removers to allow insufflation distal to both.

FIG. **31** illustrates another embodiment of a lid **418'** for use with a fluid remover. In this embodiment, rather than including a cut-out **448** formed in a sidewall of the lid **418** for allowing air to pass by the lid **418** in a proximal direction toward the seals, the lid **418'** includes a plurality of holes or openings **448'** formed therein and positioned radially around a perimeter of the lid **418'**. The lid **418'** can include any number of holes at any location and having any size. The holes **448'** are merely configured to prevent the fluid remover from forming a seal, if not needed, as it may be desirable to maintain a zero pressure differential across the fluid remover in order to prevent air from forcing fluid out of the sorbent.

FIGS. **32**A-**32**D illustrate yet another embodiment of a trocar **500** having a fluid remover **530** disposed therein. As shown, the trocar **500** has a proximal housing **502** and a distal cannula **504** with a working channel **508** formed through and extending between proximal and distal ends thereof. As shown in FIG. **32**B, the housing **502** can include an instrument seal, such as a deep cone seal **512** (only a proximal rim is shown), positioned within a channel seal, such as a duckbill seal **510**. A person skilled in the art will appreciate that any number, type, and configuration of channel and/or instrument seals can be positioned within the housing **502**. The housing can also include an insufflation port **506** is formed in the housing **502** for providing an insufflation gas to the working channel **508**.

In this embodiment, the fluid remover **530** differs from fluid remover **430** described above in that it is positioned more distal relative to the insufflation port. In general, the fluid remover **530** has an opening **570** formed through a center portion thereof, in axial alignment with the working channel **508**, for receiving a surgical instrument. The opening **570** can be effective to remove fluid from a surgical instrument upon insertion and/or withdrawal therethrough. The fluid remover **530** is positioned distal to the seals **512**, **510** so that fluid can be removed from the surgical instrument before it is withdrawn through the seals **512**, **510** in order to prevent the deposit of fluid on the seals. As with fluid remover **430**, fluid remover **530** can have a configuration that allows the passage of insufflation gas from the port **506** to the distal cannula **504** even when an instrument is disposed through the fluid remover **530**. In particular, in this embodiment the fluid remover **530** is generally positioned in the pathway of the lumen **560** of the insufflation port **506** and more particularly, it is positioned such that the longitudinal axis LA of the lumen **560** extends through a substantially center portion of the scraper lid **518**. The proximal-most interior surface **562** of the port is thus generally aligned with a top wall **556** of the scraper lid **518**. As shown in FIG. **32**B, the scraper **522** is thus positioned distal to the longitudinal axis LA of the lumen **560** and can generally be positioned in alignment with the distal-most interior surface **564** of the lumen **560**. In other embodiments, the scraper **522** can be positioned entirely distal or proximal to the distal-most interior surface **564** of the lumen **460**. A person skilled in the art will appreciate that the fluid remover **530** can be positioned in any number of ways relative to the lumen **560**.

Since portion of the lid **518** and the scraper **522** are positioned in the path of insufflation, the lid **518** and scraper **522** in this embodiment can each have a cut-out **548**, **546** that is positioned within the pathway of the insufflation gas to allow the gas to flow into the working channel **508**, as shown in FIG. **32**D. The cut-outs **548**, **546** can align with the corresponding cut-outs **526**, **544** in the crown **520** and the sorbent **514**, respectively, similar to the crown **420** and sorbent **414** discussed above. As further shown in FIG. **32**D, the scraper lid **518** can also include a rim or flange **550** extending around a proximal portion thereof and located proximal to the cut-out **548** formed in the sidewall of the scraper lid **518**. As a result, the notch **546** is not a complete cut-out, but is defined on three sides by two opposed notch side walls **552***a*, **552***b*, and a top wall **556** and thus the top wall **556** can optionally serve as a proximal, sealed boundary for the insufflation gas pathway that will be described below. In an exemplary embodiment, the top wall **556** can be positioned in alignment with the proximal-most interior surface **562** of the lumen **560** in the insufflation port.

Another exemplary embodiment of a trocar is illustrated in FIGS. **33**A-**39**. As shown in FIG. **33**A, a surgical access device or trocar **600** is provided. While the trocar **600** can have many configurations, it can generally include a housing **602** with a cannula **604** extending distally therefrom. The housing **602** and the cannula **604** can define a working channel **606** extending longitudinally through a center thereof for receiving a surgical instrument. An insufflation port **612** can be coupled to one side of the housing **602** for providing insufflation to the trocar **600**. In some embodiments, a fluid removal system which can include a scraper, a wicking element, and/or a sorbent, can be disposed within the housing **602**. While the insufflation port **612** can be disposed at many locations on the housing **602**, in this particular embodiment, the insufflation port **612** is positioned proximal to the fluid removal system and offset from the working channel **606** such that insufflation gas introduced into the housing by the insufflation port **612** passes distally through the fluid removal system to insufflate the cannula **604** and the body cavity when a surgical instrument is disposed within the working channel. A seal system can also be disposed within the housing **602** to prevent the escape of insufflation gas.

The trocar **600** is illustrated in more detail in FIG. **33**B. In some embodiments the housing **602**, and optionally the cannula **604**, can be a single, integrally formed component, such as in some of the embodiments described above. In other embodiments, such as that illustrated in FIG. **33**B, the housing **602** can include a proximal housing **608** and a separate distal housing **610** that couple together to form the housing **602**. The proximal housing **608** and the distal housing **610** can enclose the various components of the trocar **600**, such as the seal system and the fluid removal system. For example, the proximal and distal housings **608**, **610** can enclose a seal system that can generally include a zero-closure seal and an instrument seal, for example, a duckbill seal **616** and a deep-cone seal **618**, respectively. The seal system can further include an inner seal retainer **626** for holding and forming a seal with the various internal components, as will be described in more detail below.

The proximal and distal housings **608**, **610** can also enclose the fluid removal system, which can be disposed distal to the insufflation port **612**. As noted above, and as shown in FIGS. **33**B and **38**A, the fluid removal system can generally include a scraper **620** for scraping fluid from a surgical instrument inserted therethrough, a wicking element **622** disposed on the scraper (shown in FIG. **38**A) for transferring scraped fluid away from the surgical instrument, and/or a sorbent **624** for retaining fluid away from the surgical instrument. Since the insufflation port **612** can be disposed within the housing **602** at a location proximal to the fluid removal system, in general, the fluid removal system can have an insufflation pathway formed therethrough, indicated by arrow A in FIG. **33**B, to allow the passage of insufflation gas from a proximal portion of the trocar **600** to a distal portion thereof so that the area below the sealing system, including the cannula **604** and the body cavity, can be pressurized. The pathway can be offset from the working channel **606** so that insufflation gas can pass through the fluid removal system even when a surgical instrument is disposed within and occludes the working channel **606** of the trocar **600**. These and other aspects will be described in detail below.

The components of the housing **602** are illustrated in more detail in FIGS. **34**A-**35**, and the proximal housing **608** is shown in detail in FIGS. **34**A and **34**B. The proximal housing **608** can generally be a substantially rigid, hollow component designed to enclose and retain the seal system and to receive the insufflation port **612** and stopcock **614**. The proximal housing **608** can have many configurations, but in the illustrated embodiment, it has a proximal endwall **632** with a sidewall **633** extending substantially orthogonally and distally therefrom. The proximal housing **608** can be generally open distally, without a distal endwall, to allow the distal end to mate to the distal housing. A cavity formed in the proximal housing can house the various inner components of the trocar **600** when the proximal housing **608** is combined with the distal housing **610**.

In some embodiments, the proximal endwall **632** can include an opening **628** for receiving a surgical instrument therethrough and for defining the working channel **606** extending along a central longitudinal axis of the trocar **600**.

A substantially rigid, cylindrical central lumen **630** can extend from the opening **628** a distance into the proximal housing **608** to define the working channel **606**. The central lumen **630** can also serve to guide a surgical instrument into the seal system. One or more mating elements **648** can be formed in the proximal endwall **632** of the proximal housing **608** for mating with an obturator for inserting the trocar **600** into tissue.

The proximal endwall **632** and the sidewall **633** of the proximal housing **608** can have an exterior surface **635** and an interior surface **634** that can have any shape as desired to provide the required interior space. The sidewall **633** can optionally include a bowed or distended portion **636** having an opening or cut-out **638** for receiving the insufflation port **612**. The sidewall **633** can also include a distal rim **641** that is configured to mate with a corresponding proximal rim **664** (shown in FIG. **35**A) of the distal housing **610**. The proximal rim **664** and the distal rim **641** can be mated together using any technique known in the art, including but not limited to, interference fit, press fit, adhesive, fastener, etc. For example, the proximal housing **608** can include one or more coupling members **640** for mating to the distal housing **610**. The illustrated embodiment includes four coupling members **640** each extending from a coupling lumen **642**. The lumens **642** can be integrally formed with and/or rigidly coupled to the interior surface **634** of the sidewall **633**, and the coupling members **640** can extend distally therefrom. The coupling members **640** can be substantially rigid, elongate pin-like components that are configured to be disposed within corresponding coupling lumens **666** (shown in FIG. **35**A) of the distal housing **610**. When the coupling members **640** are mated with the lumens **666**, a secure coupling can be formed between the proximal and distal housings **608**, **610** by way of, for example, an interference fit, a press fit, or an adhesive. A person having ordinary skill in the art will appreciate the variety of ways that the proximal and distal housings **608**, **610** can be mated together.

In one embodiment, each coupling lumen **642** can have a protrusion or rib **643** extending radially outward therefrom, as shown in FIG. **34**B. While the ribs **643** can have many configurations, in the illustrated embodiment, the ribs **643** are rectangular shaped protrusions that generally extend along a length of the coupling lumen **642**. Two of the ribs **643** located on one side of the cut-out **638** can be orientated toward one another and the other two ribs **643** located on the opposite side of the cut-out **638** can be oriented toward one another, as shown in FIG. **34**B. The ribs **643** can be configured to engage pads **693** formed on a flange **691** of the inner retainer **626** (shown in FIGS. **36** and **37**A). The ribs **643** can prevent the inner retainer **626** from floating within the proximal and distal housing **608**, **610** and can thereby ensure adequate compression of the seals **616**, **618** and the scraper **620** to maintain a pneumo seal. In particular, the ribs **643** can ensure that the gap between a proximal sealing flange **644** of the proximal housing **608** and a proximal retainer rim **680** of the retainer **626** is of an appropriate height to provide the desired compression of the seals **616**, **618** disposed within the gap. For example, when the proximal housing **608** is fully seated on and mated with the distal housing **610**, a distal end **637** of each rib **643** abuts and engages a corresponding pad **693** on the flange **691** of the inner retainer **626**. The distance between the distal end **637** of each rib **643** and the proximal sealing flange **644** of the proximal housing **608** can set the gap between the proximal sealing flange **644** and the proximal retainer rim **680** of the retainer **626** (described in more detail below). In this way, the amount of compression on the seals **616**, **618** seated therebetween can be predicted. Similarly, the length of the ribs **643** can also set the gap between the inner retainer **626** and the distal housing **610**, thus controlling the amount of compression of the scraper **620**, also described in more detail below.

The proximal housing **608** can also include features for retaining and sealing against the seals **616**, **618**. For example, in some embodiments, the proximal housing **608** can include a proximal sealing flange **644** formed on an interior surface **646** of the proximal endwall **632**, as shown in FIG. **34**B. The proximal sealing flange **644** can be a substantially rigid cylindrical member having a diameter greater than a diameter of the central lumen **630**, but less than a width of the proximal housing **608**. In general, the proximal sealing flange **644** can act with the seal retainer **626** to retain and form a seal with the duckbill seal **616** and the deep-cone seal **618**, as will be described in detail below.

The distal housing **610** can also have many configurations and one embodiment is shown in more detail in FIGS. **35**A and **35**B. Similar to the proximal housing **608**, the distal housing **610** can generally be a substantially rigid, hollow component designed to enclose and retain the fluid removal system and to receive the insufflation port **612**. The distal housing **610** can have many configurations, but in the illustrated embodiment it has a distal endwall **652** with a sidewall **654** extending substantially orthogonally and proximally therefrom. The distal housing **610** can be generally open proximally, without a proximal endwall, and the sidewall **654** can define a cavity made for housing the various inner components of the trocar **600** when the distal housing **610** is combined with the proximal housing **608**.

The distal housing **610** can also generally be configured for receiving a surgical instrument therethrough and it can be configured to mate with the insufflation port **612** and the proximal housing **608**. For example, the distal housing **610** can include an opening **650** formed in its distal endwall **652** for receiving a surgical instrument therethrough and for defining the working channel **606** extending into the cannula **604**. In some embodiments, the distal endwall **652** and the sidewall **654** can have an exterior surface **656** and an interior surface **658** and can have any shape as desired that provides the required interior space. The sidewall **654** can optionally include a bowed or distended portion **660** that includes an opening or cut-out **662** for receiving the insufflation port **612**. The sidewall **654** can also include a proximal rim **664** that is configured to mate with a corresponding distal rim **641** (shown in FIG. **34**B) of the proximal housing **608**. The proximal rim **664** and the distal rim **641** can be mated together using any technique known in the art, including but not limited to, interference fit, press fit, adhesive, fastener, etc. For example, the distal housing **610** can include one or more coupling lumens **666** for mating to the proximal housing **608**. The illustrated embodiment includes four coupling lumens **666** each integrally formed with and/or rigidly coupled to the interior surface **658** of the sidewall **656**. The coupling lumens **666** can be substantially rigid, hollow components that are configured to receive corresponding coupling members **640** (shown in FIG. **34**B) of the proximal housing **608** to securely mate the proximal and distal housings **608**, **610** together as described above.

The distal housing **610** can also include features for retaining and sealing against the scraper **620**. For this purpose, the distal housing **610** can include a distal sealing flange **668** formed on the distal endwall **652**. The distal sealing flange **668** can be a substantially rigid cylindrical member having a diameter greater than a diameter of the opening **650**, but less than a width of the distal housing **610**.

In general, the distal sealing flange **668** can act with the seal retainer **626** to retain and form a seal with the fluid removal system, as will be described in detail below. In addition, the distal housing **610** can include a plurality of ridges **651** that are designed to seat and mate with the scraper **620** as will be described in detail below. The ridges **651** can be formed integrally with a proximal surface of a wall **736** extending from the floor of the distal housing **610**, and can have high and low portions that define each ridge **651**.

A cavity **670**, shown in FIG. **35**A, can be formed between the opening **650** and the distal sealing flange **668** for seating the sorbent **624**. The cavity can have one or more ridges, for example, a plurality of ridges **672** formed around an interior surface of the distal sealing flange **668** for providing frictional engagement with the sorbent **624**. The cavity **670** can also include a plurality of features, for example, four nubs **671** that extend proximally from the floor of the cavity **670** and that are designed to engage the sorbent **624** and press the sorbent **624** into engagement with the scraper **620** as will also be described in more detail below. As will be appreciated by those skilled in the art, any sort of feature sufficient to press the sorbent **624** into engagement with the scraper **620** can be used within the cavity **670**. The nubs **671** can be formed integrally with the distal housing **610** or can be coupled thereto by an adhesive or other fixation mechanism.

The distal housing **610** can optionally be integrally formed with the cannula **604**. The cannula **604** can extend distally from the distal housing **610** and can terminate distally in an angled portion that forms a distal piercing tip **605** that facilitates entry through tissue into a body cavity. In some embodiments, a longest point of the angled distal tip **605** of the cannula **604** can be oriented relative to the distal housing **610** such that it is aligned with the insufflation port **612**, although it can have any orientation desired. The distal housing **610** can also have one or more suture loops or other suture tie down features **675** formed around an outer perimeter of an exterior surface **656** thereof. Each suture tie down feature **675** can define an opening or pathway formed therethrough for receiving suture to help better secure the trocar **600** when it is disposed in tissue. The suture tie down feature **675**, shown in FIG. **33**A, can have any angular orientation relative to the angled distal tip **605** of the cannula **604**, but in one embodiment, at least one tie down feature **675** is offset by 90 degrees from the longest point of the angled distal piercing tip **605**. In other embodiments, the suture tie down feature **675** can be positioned in line with the angled distal tip **605** of the cannula **604**, or offset by 180 degrees therefrom.

While the seal system and fluid removal system disposed within the housing **602** can have many different configurations, one exemplary embodiment of these systems is shown in more detail in FIG. **36**. As noted above, the illustrated seal system includes a duckbill type channel seal **616**, a deep-cone type instrument seal **618**, and an inner seal retainer **626** for securing the sealing elements within the trocar **600**. As will be appreciated by those having ordinary skill in the art, any suitable sealing combination can be utilized within the housing **602** that is effective to maintain insufflation of the cannula **604** and the body cavity during use. Thus, the sealing combination can generally include both a zero-closure seal and an instrument seal and/or a single seal that is capable of both zero-closure and sealing around an instrument. In the illustrated embodiment, the deep-cone seal **618** is disposed within the duckbill seal **616** such that an instrument inserted into the working channel **606** through the opening **628** in the proximal housing **608** will encounter the deep-cone seal **618** first. Since it is positioned proximal to the duckbill seal **616**, the deep-cone seal **618** will form a seal around the surgical instrument before the surgical instrument encounters and opens the duckbill seal **616**. In this way, insufflation can be maintained during insertion of the instrument into the trocar **600**.

While there are various ways to retain the seals within the housing **602**, in the illustrated embodiment, the seals **616**, **618** are disposed within and coupled to the seal retainer **626**. The seal retainer **626** and the proximal and distal housings **608**, **610** can generally function together to seal the working channel **606** by pressing and sealing against a perimeter of the seals **616**, **618**. In particular, as shown in FIGS. **36**-**37**B, the seal retainer **626** can be a substantially rigid cylindrical component that defines a portion of the working channel **606** and seals the working channel **606** from a region in the housing **602** outside of and/or surrounding the retainer **626**. The seal retainer **626** fits within the housing **602** and that can have a proximal end **706** and a distal end **702**. The proximal end **706** can have an opening **700** that is substantially the same diameter as an outer diameter of the retainer **626**, although it can have any diameter as necessary to accommodate the seals **616**, **618**. The distal end **702** can include a distal endwall **708** with an opening **704** extending therethrough. The opening **704** can have any diameter as needed, for example, a diameter that is smaller than the outer diameter of the retainer **626**, but at least large enough to receive a surgical instrument. The retainer **626** can have a sidewall **711** extending between its proximal and distal ends **706**, **702**. In some embodiments, the distal endwall **708** can include a plurality of ribs **707** extending radially from the opening **706**, as shown in FIG. **37**C. The ribs **707** can be configured for maintaining positive contact between the scraper **620** and the sorbent **624**.

As noted above, in some embodiments the seals **616**, **618** can be retained by and sealed between the seal retainer **626** and the sealing flange **644** of the proximal housing **608**. In particular, the retainer **626** can have a proximal retainer rim **680** that can engage a distal surface **682** of a flange **684** formed on the duckbill seal **616**. The proximal sealing flange **644** of the proximal housing **608** can engage the proximal surface **686** of the flange **688** on the deep-cone seal **618**. As shown most clearly in FIG. **33**B, when the trocar **600** is assembled, the proximal retainer rim **680** and the proximal sealing flange **644** compress together around the outer perimeter of the flanges **684**, **688** and form a seal thereagainst such that the working channel **606** is sealed for the purposes of insufflation. As well, the proximal rim **680** and the sealing flange **644** can retain the seals **616**, **618** within the housing **602**. As noted above, the amount of spacing between the distal end **637** of the ribs **643** in the proximal housing **608** and the proximal sealing flange **644** of the proximal housing **608** can be used, at least in part, to predict and control the amount of compression of the seals **616**, **618**.

As also noted above, at least a portion of the fluid removal system can be retained by and sealed between the seal retainer **626** and the sealing flange **668** of the distal housing **610**. In particular, the seal retainer **626** can include a distal retainer rim **690** that can engage a proximal surface **692** of the scraper **620**. In addition, the distal sealing flange **668** in the distal housing **610** can engage a distal surface **694** of the scraper **620**. When the trocar **600** is assembled, the distal retainer rim **690** and the distal sealing flange **668** compress together around the outer perimeter of the scraper **620** to form a seal thereagainst such that the working channel **606** is sealed for the purposes of insufflation. As well, the distal rim **690** and the sealing flange **668** can retain the scraper **620** within the housing **602**.

As shown in FIGS. **33**B, **36**, and **37**A the seal retainer **626** can further include a median flange **691** extending radially outward from the retainer **626** and disposed around an outer circumference thereof. The median flange **691** can generally be disposed anywhere along a length of the retainer **626**, but in the illustrated embodiment it is disposed near a mid-portion of the retainer **626**. The median flange **691** can be configured to engage an inner sidewall of the proximal and distal housings **608**, **610** at a point where the proximal and distal housings **608**, **610** mate together. In this way, the retainer **626** can be retained and secured within the housing **602**. As noted above, the flange **691** can also include a plurality of pads **693** configured to engage ribs **643** in the proximal housing **608**. The length of the ribs **643** can be used to predict and control the compression of the seals **616**, **618** and the scraper **620**. In some embodiments, the median flange **691** can have a portion **710** that curves or dips distally to accommodate the structure of the proximal and distal housings **608**, **610** near the coupling point for the insufflation port **612**.

In some embodiments, the seal retainer **626** can also include a port **696** for receiving the insufflation port **612**. An opening **706** can be formed in a distal endwall **708** of the retainer **626** to allow insufflation gas to flow from the port **696** and through the distal endwall **708** to insufflate the cannula **604** and the body cavity.

As noted above, the trocar **600** can include a fluid removal system generally configured to remove fluid from a surgical instrument and transfer and store the fluid at a location away from the working channel **606** and any surgical instrument inserted therethrough. The fluid removal system can have many configurations, but as shown in FIG. **36**, and as noted above, it can include the scraper **620** having the wicking element **622** formed thereon (shown in FIG. **38**A) and the sorbent **624** positioned adjacent to the scraper **620** to sorb fluids wicked by the wicking element **622**.

The scraper **620** is shown in more detail in FIGS. **38**A-**38**C and can have any of the same or similar features and configurations previously described. The scraper **620** can be a substantially circular component having a proximal surface **722** and a distal surface **694**. An opening **712** can be formed through a center of the scraper **620** for receiving a surgical instrument therethrough. The opening **712** can have a diameter substantially the same as, or slightly smaller than, a diameter of a surgical instrument inserted therethrough so that the opening **712** scrapes along the outside of a surgical instrument as it is passed therethrough to remove fluid therefrom. As noted in the previous embodiments, the scraper **620** can be formed of a flexible material and can therefore invert proximally as a surgical instrument is being withdrawn through and scraped by the opening **712**.

There are many ways in which the scraper **620** can be retained within the housing **602**. As noted above, in one embodiment the scraper **620** can be retained by and disposed between the distal retainer rim **690** of the retainer **626** and the distal sealing flange **668** of the distal housing **610**. Because the scraper **620** can be formed of a flexible and/or compressible material, as the rim **690** and the flange **668** engage the outer perimeter of the scraper **620**, the outer perimeter of the scraper **620** can be compressed therebetween and a seal can be formed between the scraper **620**, the rim **690**, and the flange **668**. As noted above, the amount of spacing between the distal end **637** of the ribs **643** in the proximal housing **608** and distal retainer rim **690** can be used, at least in part, to predict and control the amount of compression of the scraper **620**. The outer perimeter of the scraper can optionally include a lip **724** extending proximally from the proximal surface **722**. The rim **690** and the flange **668** can compress the scraper **620** at a location radially inward of the lip **722**, as can be seen in FIG. **33**B.

In some embodiments, the scraper **620** can include features to assist in securing the scraper **620** within the housing **602**. For example, the outer-most perimeter of the scraper **620** can include one or more indentations, for example, four indentations **714** for receiving protrusions **716** in the distal housing **610**. The protrusions **716** are coupled to and/or integrally formed with the lumens **666** and serve to further stabilize the scraper **620** within the distal housing **610**. The scraper **620** can also include an opening or hole **718** that can align with the opening **706** formed in the retainer **626** to allow insufflation gas to flow therethrough. The hole **718** can have any size or shape known in the art that is sufficient to allow the flow of insufflation gas therethrough. In the illustrated embodiment, the hole **718** is substantially rectangular and of a size to match the opening **706**. The hole **718** can be offset from the opening **712** such that an axis extending through the center of the hole **718** that is parallel with the longitudinal axis of the trocar **600** is offset a distance away from the longitudinal axis of the trocar **600**.

As noted above, the scraper **620** can also include features formed thereon, such as the wicking element **622**, for wicking fluid away from the working channel **606**. While the wicking element **622** can take any form suitable to wick fluid away from the opening **712**, in the illustrated embodiment, the wicking element **622** can be one or more channels **720** formed in the distal surface **694**. The channels **720** can extend partially into the distal surface **694** of the scraper **620** and can have a depth suitable to contain and transfer fluid away from the opening **712**. The channels **720** can begin at the opening **712** and extend radially outward therefrom, or they can begin a radial distance away from the opening **712** and extend radially outward therefrom, as shown in FIGS. **38**A and **38**C. Similarly, the channels **720** can extend all the way to the outer-most circumference of the scraper **620**, or they can stop a distance away from the outer-most circumference, as shown in FIG. **38**A. A person skilled in the art will appreciate the variety of configuration possible for the channels **720**.

There can also be any number of channels **720** formed in the scraper **620** as desired and they can be arranged around the scraper **620** with even spacing therebetween and/or with uneven spacing therebetween. In the illustrated embodiment, a plurality of channels **720** are formed in the scraper **620** and the majority thereof are generally spaced evenly around the scraper **620**. However, channels **720** near the hole **718** can differ is spacing. For example, four of the channels **720** near the hole **718** are not spaced evenly with the other channels **720**. Instead two channels **720** on one side of the hole **718** and two channels **720** on the other side of the hole **718** are spaced closer together to provide room for the hole **718** and to ensure that fluid is directed away from the hole **718**. As noted above, the scraper **620** can be seated on the ridges **621** formed on the wall **736** of the distal housing **610**. In particular, the ridges **621** can engage a narrow circumference of the scraper **620** that is closer to the center opening **712** than to the outer-most circumference, for example about one-quarter to one-third of the way along a length of the channels **720**, although any configuration is possible. This narrow circumference of engagement allows the scraper **620** to be seated within the distal housing **610** without causing the channels **720** to buckle or collapse, as would likely happen with a wider area of engagement. The channels **720** can be aligned with the ridges **621**, as illustrated in FIG. **38**C, such that each channel **720** is aligned with a low portion or valley of the ridges **621** to ensure fluid flow through the channel **720**. Each high portion or peak of the ridges **621** extends proximally between the channels **720**. The channels **720** can be adjacent to and in contact with the sorbent **624** to wick fluid to the sorbent **624**.

The sorbent **624** can also have many shapes and configurations, as noted in detail above. In the embodiments illustrated in FIGS. **36** and **39**, the sorbent **624** can be substantially c-shaped and/or substantially circular shaped with a cut-out **730** in one side. A center opening **727** of the sorbent **624** can have a diameter that is greater than a diameter of the working channel **606** of the cannula **604** and/or of the opening **712** formed in the scraper **620**. The sorbet **624** can have a proximal surface **726** and a distal surface **728**, as well as an outer surface **732** and an inner surface **734**. The sorbent **624** can generally have a rectangular cross-section with a width W and a height H, and in some embodiments, the width W can be less than a height H. In other embodiments, the sorbent **624** can have a circular cross-section, a triangular cross-section, etc. The sorbent **624** can generally have a size suitable to be positioned within the cavity **670** formed within the distal housing **610**. The cut-out **730** can have any width and configuration, and in the illustrated embodiment it has a width similar to but larger than the size of the hole **718** in the scraper **620** and the opening **706** in the retainer **626**. For example, the cut-out **730** can have a width larger than parallel walls **677** within the distal housing **610** defining an insufflation pathway **674** through the distal housing **610**. The hole **718** in the scraper **620** and the opening **706** in the retainer **626** can have a width substantially the same as the width of the walls **677** in the distal housing **610**. The larger width of the cut-out **730** compared with the width of the hole **718** and the opening **706** is to ensure that the insufflation pathway remains clear of any fluid retained in the sorbent **624**. In use, the cut-out **730** is preferably aligned with the hole **718** and the opening **706**.

As noted above, the sorbent **624** can be seated within the cavity **670** and on top of the nubs **671**. The nubs **671** can engage the distal surface **728** of the sorbent **624** and can elevate the sorbent **624** to bias the sorbent **624** into engagement with the scraper **620**. In particular, the proximal surface **726** of the sorbent **624** can be pressed into engagement with the distal surface **694** of the scraper **620**. In some embodiments there can be a compression force that results in an interference contact between the surfaces **726**, **694** in the range of about 1/1000 to about 18/1000 inches to ensure sufficient contact between the two surfaces **726**, **694** without blocking the channels **720** and preventing fluid transfer. The engagement between the two surfaces **726**, **694** provided by the nubs **671** results in efficient transfer of fluid from the channels **720** of the wicking element **622** to the sorbent **624**. Fluid scraped by the opening **712** can travel radially outward from the opening **712** through the channels **720**, past the ridges **621**, and into contact with the sorbent **624** to be sorbed thereby.

When the trocar is assembled, all of the holes, openings, and pathways through the various components of the fluid removal system can be aligned to form an insufflation pathway through the fluid removal system, as shown by arrow A in FIG. **33**B. More particularly, the sorbent **624** can be positioned within the cavity **670** within the distal housing **610**. Ridges **672** can engage the outer surface **732** of the sorbent **624**, while the inner surface **734** engages a wall **736** defining the opening **650** that extends into the cannula **604**. Opposed sides **738***a*, **738***b* of the cut-out **730** can be positioned on either side of the channel or pathway **674** extending from the opening **650** within the distal housing **610**. The pathway **674** can be aligned with the port **696** of the retainer **626** to allow the insufflation gas to flow therethrough. The scraper **620** can be positioned on top of or proximal to the sorbent **624** such that the outer perimeter of the scraper **620** rests on the distal sealing flange **668** of the distal housing **610**, and such that the wicking element **622** is adjacent to and in contact with the sorbent **624**. In this way, fluid scraped by the scraper **620** will be wicked along the channels **720** and sorbed by the sorbent **624**. The sorbent **624** will hold the fluid away from the working channel **606**, and thus away from any instruments inserted through the working channel **606**. The hole **718** in the scraper **620** can be aligned with the pathway **674** in the distal housing **610** and with the cut-out **730** in the sorbent **624** to allow the flow of insufflation gas therethrough.

Further, the seal retainer **626** can be positioned proximal to the scraper **620** such that the distal rim **690** is positioned on the proximal surface in contact with the outer perimeter of the scraper **620** and forms a seal thereagainst with the distal sealing flange **668**. The opening **706** in the retainer **626** can also be aligned with the hole **718** in the scraper **620**, the cut-out **730** in the sorbent **624**, and the pathway **674** in the distal housing **610** to form the insufflation pathway to allow the flow of insufflation gas therethrough. In this way, insufflation gas from the port **696** passes from an area in the distal housing **610** that is proximal to the fluid removal system through the pathway created by the opening **706**, the hole **718**, the cut-out **730**, and the pathway **674** and into an area distal to the fluid removal system. The insufflation gas can therefore pass into the cannula **604** and into the body cavity through the fluid removal system even when a surgical instrument occludes the opening **712** in the scraper **620**.

In use, once the trocar **600** is inserted into a body cavity, the insufflation port **612** can be used to introduce insufflation gas into the housing **602** through the port **696** in the seal retainer **626**. In other embodiments, insufflation gas can be introduced into the housing **602** before an instrument is inserted therethrough. The gas can flow into the channel **740** in the retainer **626** near the distal end of the duckbill seal **616** shown in FIG. **33**B, and into the insufflation pathway created through the fluid removal system as described above, as well as through the working channel **606**. When an instrument is disposed through the trocar **600**, the deep-cone seal **618** forms a seal around the instrument to maintain insufflation distal of the seal **618**. Further, the surgical instrument occludes the opening **712** in the scraper **620**, preventing the flow of gas through the working channel **606**. The insufflation pathway that extends through the fluid removal system is offset from the working channel **606**, and thus insufflation gas can flow through the insufflation pathway in the direction of arrow A, shown in FIG. **33**B, as described above.

As a surgical instrument is withdrawn from the trocar **600**, it is pulled through the opening **712** in the scraper **620**. The opening **712** can scrape fluid from the outside of the surgical instrument. The fluid can travel into the wicking channels **720** and be wicked away from the opening **712**. The channels **720** can transfer the fluid to the sorbent **624**, where it is held away from the opening **712** so that any subsequently inserted surgical instruments will not be contaminated by fluid. It will be appreciated by those having ordinary skill in the art that the order of use and/or method steps is not important and thus can be performed in any order.

In another embodiment, all of the above described fluid remover embodiments can be formed into a single “drop-in” unit as needed. The drop-in unit can include sorbent elements, scraper elements, wicking elements, and/or combinations thereof. These elements can be combined as needed into an externally configured unit that can be placed into an existing trocar system as needed. Thus, the drop-in unit will fit in and around any seals and components disposed within the proximal housing, including the removable cap, and/or within the cannula. For example, the drop-in unit can be configured to fit below or distal to one or more sealing elements and/or it can be configured to fit above or proximal to one or more sealing elements. Alternatively or in addition, the drop-in unit can be configured to have components that fit above, below, or in between sealing elements. The drop-in unit can also include the seals therein such that the entire unit can be placed into an empty housing of a trocar. The drop-in unit can also be removable as needed, and the unit, or portions thereof, can be reusable.

Methods for removing fluid from a surgical instrument are also generally provided. In an exemplary embodiment, a surgical instrument can be passed through an access device and a fluid remover in the access device can remove any fluid on the instrument, or fluid deposited on a seal within the access device by the instrument. In one exemplary embodiment, a fluid remover can engage a surgical instrument passed through an access device, such as a trocar, upon removal of the instrument to thereby remove fluid from the instrument, thus preventing the fluid from accumulating on the seal(s) and/or from being redeposited on instruments passing therethrough. As indicated above, the fluid remover can be formed from any combination of one or more sorbing, scraping, and wicking elements. A person skilled in the art will appreciate that virtually any combination of sorbing, scraping, and wicking elements can form the fluid remover resulting in a variety of methods for removing fluid that can include any combination of sorbing, scraping, and wicking fluid away from a surgical instrument and/or from a seal or other portion of a trocar or other access device.

A person skilled in the art will appreciate that the present invention has application in conventional endoscopic and open surgical instrumentation as well application in robotic-assisted surgery.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. By way of non-limiting example, the scraper and/or sorbent can be removed, cleaned, re-coated with a hydrophilic material, sterilized, and reused. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the devices described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and its contents are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

It is preferred that device is sterilized. This can be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, steam.

One skilled in the art will appreciate further features and advantages of the invention based on the above-described embodiments. Accordingly, the invention is not to be limited by what has been particularly shown and described, except as indicated by the appended claims. All publications and references cited herein are expressly incorporated herein by reference in their entirety.

What is claimed is:

1. A surgical access device, comprising:

a proximal housing, a distal cannula, and a working channel extending through the proximal housing and the distal cannula that is sized and configured to receive a surgical instrument;

a seal disposed within the proximal housing configured to seal the working channel when no surgical instrument is disposed therethrough, the seal having an opening extending therethrough and positioned to receive a surgical instrument passed through the working channel; and

a fluid remover positioned distal of the seal, the fluid remover having an opening extending therethrough and positioned to receive a surgical instrument passed through the working channel, and the fluid remover being configured such that, when an instrument occludes the opening in the fluid remover, the fluid remover allows insufflation gas to pass between a proximal side of the fluid remover and the distal cannula to thereby equalize a pressure on proximal and distal sides of the fluid remover.

2. The surgical access device of claim **1**, wherein the fluid remover is positioned such that it is configured to be in a pathway of an insufflation gas flowing from an insufflation port formed in the proximal housing.

3. The surgical access device of claim **1**, wherein the fluid remover includes a cut-out formed in at least a portion thereof and configured to allow an insufflation gas to pass from an insufflation port, through the cut-out, and into the distal cannula when an instrument occludes the opening.

4. The surgical access device of claim **1**, wherein the fluid remover includes a scraper configured to scrape fluid off of a surgical instrument passed through the opening.

5. The surgical access device of claim **4**, wherein the fluid remover includes a sorbent positioned to sorb fluid removed by the scraper.

6. The surgical access device of claim **5**, wherein the sorbent is positioned distal to an insufflation port.

7. The surgical access device of claim **5**, wherein the sorbent is disposed around a substantially cylindrical member.

8. The surgical access device of claim **4**, wherein an insufflation port has a lumen extending therethrough and defining a longitudinal axis, and wherein the scraper is positioned distal to the longitudinal axis.

9. The surgical access device of claim **1**, wherein at least a portion of the fluid remover is positioned distal to an insufflation port.

10. A surgical access device, comprising:

a housing defining a working channel sized and configured to receive a surgical instrument;

a seal disposed within the housing, the seal having an opening positioned to receive a surgical instrument passed through the working channel;

a sorbent disposed in the housing and configured to sorb fluid to prevent fluid from being redeposited on surgical instruments passed through the working channel; and

a scraper disposed in the housing and configured to scrape fluid off of surgical instruments passed through the working channel, the scraper being in contact with a proximal surface of the sorbent.

11. The surgical access device of claim **10**, wherein the sorbent is positioned to sorb fluid away from the opening in the seal.

12. The surgical access device of claim **10**, wherein the sorbent comprises an absorbent.

13. The surgical access device of claim **10**, wherein the sorbent comprises an adsorbent.

14. The surgical access device of claim **10**, wherein the housing includes a proximal portion containing the seal and a distal cannula extending distally from the proximal portion and configured to be inserted into a body cavity.

15. The surgical access device of claim **14**, wherein the seal comprises a first seal, and the access device further comprises a second seal disposed within the housing, and wherein the sorbent is positioned distal of the first and second seals.

16. The surgical access device of claim **10**, wherein the sorbent is configured to sorb fluid scraped by the scraper.

17. The surgical access device of claim **10**, further comprising a wicking element disposed in the housing and configured to wick fluid away from a surgical instrument passing through the working channel.

18. An assembly for use in a surgical access device, comprising:

a seal having an opening configured to receive a surgical instrument therethrough;

a sorbent associated with the seal and configured to sorb fluid away from at least one of the opening and a surgical instrument passed through the opening; and

a scraper element configured to scrape fluid off of a surgical instrument extending through the opening of the seal, the scraper element being in contact with a proximal surface of the sorbent.

19. The assembly of claim **18**, wherein the sorbent is an adsorbent element.

20. The assembly of claim **18**, wherein the sorbent is an absorbent element.

21. The assembly of claim **18**, wherein at least a portion of the scraper element is hydrophilic.

22. The assembly of claim **18**, further comprising a wicking element associated with the scraper and configured to wick away fluid collected near the opening of the seal when a surgical instrument is passed through the opening.

23. The assembly of claim **18**, further comprising a wicking element associated with the seal and configured to wick away fluid collected near the opening when a surgical instrument is passed through the opening.

24. The assembly of claim **18**, wherein the seal comprises an instrument seal configured to form a seal when an instrument is inserted therethrough.

25. The assembly of claim **18**, wherein the seal comprises a first seal, and the assembly further comprises a second seal.

26. The assembly of claim **25**, wherein the sorbent is positioned distal of the first and second seals.

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